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OUR PRESENT KNOWLEDGE OF PLANT PROTEINS[1]

To the biological chemist few substances present so many features of interest as the proteins of plants. These lie at the very foundation of the nutrition not only of plants but of animals, and from them are derived a multitude of products directly connected with physiological processes. The study of the chemistry of plant proteins, although it early interested several of the leading chemists of their time, has received in the aggregate so little attention that to-day our knowledge of this subject is but slightly advanced beyond what may properly be called a beginning. How slow the progress has been may be shown by a brief review of the literature that is on record.

HISTORICAL

In 1746, Beccari announced his discovery of a peculiar substance which he obtained by washing wheat flour with water, that had all the properties which up to that time had been considered to be characteristic of animal life only. This substance, which we now know to be wheat gluten, appears to have been for more than fifty years the only form of vegetable protein that was known, for Beccari failed to obtain similar products from other seeds.

In 1805, Einhof discovered that a part of the gluten of wheat was soluble in alcohol, and he described the existence of similar proteins in rye and barley. Einhof

[1] An address delivered before the American Chemical Society at New Haven, Conn., July 1, 1908.

overlooked the fact that only a part of the gluten of wheat was dissolved by alcohol, and he considered this property to be characteristic of all plant proteins except the "Eiweiss," which he obtained by heating the aqueous extracts of seeds and other parts of plants. When, therefore, he later discovered in leguminous seeds another form of protein which was not soluble in alcohol, but had in pronounced degree the properties of "animal matter," he assumed that he had obtained a substance belonging to a distinctly different group but yet related to the gluten or "Kleber" that had been found in other seeds.

Taddei, in 1820, showed that only a part of the wheat gluten was soluble in alcohol and he applied distinctive names to each part; gliadin to the substance soluble, and zymom to that insoluble, in alcohol.

From this time, chemists were more and more attracted to the study of vegetable proteins, and among those thus engaged are found many of the most distinguished chemists of the earlier part of the last century, such as Berzelius, Dumas, De Saussure, Boussingault, Liebig and many of his pupils.

In 1841, Liebig reviewed the work done in his and other laboratories on the properties and composition of plant proteins. The state of knowledge which then prevailed respecting this subject is well illustrated by the following quotation from his review:

> Another, in number very limited, class of nitrogenous compounds is very abundantly distributed. There are four of these substances, of which one occurs, without exception, in all plants, while the others are only constituents of certain families of plants. These are the nitrogenous food substances properly known under the names of Vegetable "Eiweiss," Pflanzenleim and legumin. . . . These substances, to which a fourth must be added, which I will name Pflanzenfibrin, are the true food substances of the plant-eating animals.

In discussing these four proteins, Liebig asserted that each was identical with the protein of animal origin bearing the corresponding name. The identity of legumin with milk casein was claimed and this protein he therefore named plant casein.

The work undertaken by Liebig was continued for twenty years or more by Ritthausen, who was one of his pupils. Ritthausen, in 1860, began the first serious study of these important substances and devoted much time and care to the production of preparations of the highest attainable purity, and to accurate determinations of their ultimate composition. His work greatly extended the scope of the prevailing knowledge of the plant proteins, and made it plain that these substances exist in much more diverse forms than had before been supposed. He also added much to our knowledge of the decomposition products of vegetable proteins by showing that they yielded many substances already obtained from proteins of animal origin, and discovered glutaminic acid which is now recognized as a constituent of practically all proteins, whatever their origin. He was also the first to obtain aspartic acid from the products of protein hydrolysis.

In 1877 Hoppe-Seyler and his pupil Weyl applied to seeds the then recently developed method of extraction by solutions of neutral salts. They showed that a large part of the protein of a number of different seeds was soluble in such solutions, and had the properties of the so-called globulins of animal origin. While the experimental work of these investigators was hardly more than qualitative and of very superficial character, the conclusions which they drew and the criticisms of Ritthausen's work which they put forth were generally accepted as final by most physiologists, and threw it into general discredit.

Although Ritthausen afterwards showed that a large part of many of his previously described preparations, which had been obtained by extraction with dilute alkalies, was soluble in solutions of neutral salts, and that the composition of many of the proteins which he had previously analyzed was the same as that of preparations obtained by extraction with solutions of sodium chloride, nevertheless physiologists continued to repeat the criticisms of Hoppe-Seyler, and the work of Ritthausen failed to receive the recognition which it deserved.

REVIEW OF THE WRITER'S WORK

Since Ritthausen ceased his work with vegetable proteins little has been done in this field outside of my own laboratory. It is true that from time to time papers have appeared dealing with special questions in the chemistry of these substances, but no other connected and extensive investigation has been described, and as the work which I have been doing during the past twenty years has now reached a point where it can be profitably reviewed, I propose to take up some of its more important features and briefly discuss them.

As Ritthausen's researches were far from exhaustive and left the subject in such a state of confusion that it was impossible to form definite conclusions respecting much that he had described, it seemed best to me to direct attention chiefly to those seeds which had been previously studied by him and by others, and to try to clear up the existing uncertainties, rather than to add to them by describing new proteins. As a result, we now have about twenty-five different proteins of vegetable origin, the important characters of most of which have been studied by all the means at present available. These proteins appear to represent the different types to be found in seeds and are, I think, sufficient in number to form a suitable foundation for the future study of their chemistry. All of these are constituents of seeds. A few of them represent constituents of the physiologically active embryo, but the majority represent the reserve food protein of the endosperm, and serve not only for the nutrition of the growing seedling, but also for the nutrition of men and animals. Of the protein constituents of other parts of plants very little indeed is known.

CHEMICAL INDIVIDUALITY OF PROTEINS

In considering the position of our present knowledge of the seed proteins, the question of chemical individuality should first be considered. We are now well past the time when agreement in solubility, ultimate composition and color reactions, are to be accepted as evidence of the identity of two preparations of protein. It is not necessary to explain why it is at present not possible to demonstrate the chemical individuality of any single protein, for the reasons are evident to all who will give this question the slightest consideration from the standpoint of the organic chemist. While it is not possible to establish the individuality of any protein, it is possible to show differences between the various forms which can be isolated, and to establish a constancy of properties and ultimate composition between successive fractional precipitations which give no reason for believing the substance to be a mixture of two or more individuals.

On the basis that agreement in ultimate composition affords no evidence of identity of two similar proteins, but that distinct and constant differences in composition are conclusive evidence that they are not alike, I have endeavored to differentiate the several seed proteins that I have studied, and have since subjected them to careful

comparisons in respect to their physical properties and the proportion of their decomposition products, so that those which are alike in their more apparent characters have been still further distinguished from one another. Whether these are in fact chemical individuals, must await the development of new methods of study. For the present they must be accepted as the simplest units with which we can deal.

SUITABILITY OF SEED PROTEINS FOR A STUDY OF PROTEIN CHEMISTRY

The various proteins thus established furnish material for further study, and are characterized by wide differences not only in physical properties, but in the proportion of their decomposition products. They can be prepared in large quantity in a high state of purity, and, being a part of the reserve food stored up for the nutrition of the developing embryo, are by nature more stable than the animal proteins which form a part of physiologically active tissues. Furthermore, they are not associated with tissues and fluids rich in other forms of protein from which they are to be separated, and they are mostly obtained in the form of dense precipitates, often crystalline, which are little inclined to adsorb other substances from which they can afterwards be separated with difficulty. Although associated intimately in the seed with many forms of soluble and insoluble carbohydrates, they can, in many cases, be separated from every trace of the latter, as is shown by appropriate reactions.

It is my firm belief that a careful examination of them will ultimately afford a better knowledge of the chemistry of proteins in general than can be obtained from proteins of animal origin. Although the problems immediately connected with the animal proteins are of greater importance to physiology than those at present recognized as connected with seed proteins, there is no question but that definite knowledge of the chemistry of seed proteins will be directly applicable to many important problems of animal physiology.

THE DIFFERENT GROUPS OF PROTEINS FOUND IN SEEDS

The seed proteins for the most part can be grouped in much the same way as the proteins of animal origin, but in so doing, it is necessary to modify to some extent the requirements to which the animal proteins belonging to some of these groups are at present assumed to conform. The necessity of some scheme of classification for the proteins is recognized by all who write or teach about them, and although the present method of classifying proteins according to their solubility is wholly unsatisfactory from a purely chemical standpoint, it is practically the only one now available. On chemical grounds there is no more reason for dividing the proteins into two groups of animal and vegetable proteins, than there is for making a similar distinction between the carbohydrates. I have, therefore, endeavored to assign the various forms of seed proteins to the commonly recognized groups established for those of animal origin, and have proposed to slightly modify the definitions usually given for these groups, but only so far as this is necessary.

1. *Globulins* form much the greater part of the reserve protein of all seeds except those of the cereals. By globulin is meant protein soluble in solutions of neutral salts but insoluble in water. This definition does not strictly apply to many of the seed proteins assigned to this group, for these behave as globulins only under certain conditions. As these conditions prevail during the extraction and isolation of these proteins and depend on the presence of free acid in the extracts, it is important

to consider the relations of the proteins to this acid.

The behavior of seed globulins toward acid is shown by studies made in my laboratory on edestin. Crystallized preparations of edestin, obtained by dialyzing or cooling sodium chloride extracts of hemp-seed, frequently contain protein in three forms; one, soluble in pure water and also in strong saline solutions, another, insoluble in water but soluble in strong saline solutions, and still another, insoluble either in water or in saline solutions. The proportion of these products varies with slight differences in the conditions under which the edestin is isolated, and plainly depends upon changes in the protein which take place during its preparation.

The explanation of these changes has been found in the presence of a small amount of acid extracted from the seed together with the protein. The part of the edestin preparation just referred to, which is insoluble in neutral saline solutions, has been found to be a product of the hydrolytic action of the acids of the extracts. This product is not the result of a profound splitting of the edestin molecule, for the changes leading to its formation are so slight that they can be detected only by the altered solubility. For such primary products of protein hydrolysis, which were designated "albuminates" by Weyl, I have proposed the name "protean" and for the products derived from the individual proteins, a corresponding name ending with the affix *an*. Thus the product derived from edestin may be called *edestan*. The part of the edestin above referred to which is soluble in water contains more combined acid than the part insoluble therein. The preparation, therefore, contains a mixture of salts of edestin. These edestin salts contain some of all the anions present in the solution at the time of precipitation, that salt being predominant whose free anion was most abundant in the solution from which the edestin was last precipitated. When freed from this combined acid by making the preparation neutral to phenolphthalein, the edestin is wholly insoluble in water, but soluble in neutral saline solutions. Edestin has, consequently, the properties of a true globulin. Other seed proteins behave towards acids in a similar way, except that some of them, when neutral to phenolphthalein, are soluble in water. Many of these latter behave as globulins when in the form of salts, and as they are obtained as salts by the methods employed in preparing them, I have for convenience, placed them among the globulins.

The fact that our protein preparations, as usually obtained, are protein salts is fundamental for a correct conception of their behavior under the conditions of isolation and purification, and for an explanation of many of their physiological relations.

The seed proteins which are described as globulins, differ in some of their properties from some of those that are commonly assumed to characterize the globulins of animal origin. In this connection, however, the fact should not be overlooked that our knowledge of animal globulins is relatively small, and it is probable that further study will modify our present conception of them. It has become customary for physiologists to consider that all *globulins* are precipitated by adding to their solutions an equal volume of a saturated solution of ammonium sulphate, and of recent years it appears to have become an almost universal practise to designate as globulin all the protein that can be thus precipitated. This practise is unfortunate and leads to confusion, for it wholly ignores the original conception of a globulin, namely, a protein soluble in neutral saline solutions but insoluble in water.

Globulins are commonly described as proteins that are coagulated by heat. This is doubtless true of the globulins of seeds if sufficient acid is present in their solutions. It is, however, difficult to add to the saline solutions of most seed globulins a sufficient amount of acid to cause complete coagulation on heating, for even a very minute quantity of acid in a strong saline solution alone precipitates a large quantity of the globulin.

The deportment of edestin in this respect is well illustrated by the experiments of Chittenden and Mendel,[2] who showed that a saline solution of edestin was only partly coagulated by boiling, that the edestin remaining in solution could be recovered unchanged and in well-formed crystals, and that addition of acid to the solution filtered from the coagulum gave rise to a new coagulum on again heating.

2. *Prolamins*[3] form a unique and sharply differentiated group of proteins which occur in quantity in the seeds of cereals, but not in those of any other plant yet examined. These are soluble in all proportions in alcohol of 70–80 per cent., and are not affected by boiling their alcoholic solutions, even for a long time. They are practically insoluble in water and saline solutions, but are soluble in dilute solutions of acids and alkalies.

The prolamins are better characterized, from a chemical standpoint, than any of the other groups of seed proteins, for on hydrolysis they all yield a very small amount of arginine and histidine and no lysine whatever. On the other hand, they yield from 20 to 30 per cent. of their total nitrogen in the form of ammonia and also contain relatively large amounts of glutaminic acid. Gliadin from wheat and rye, and the related hordein from barley, yield about 37 per cent. of glutaminic acid, which is very much more than that found in any other protein yet examined, and zein yields nearly 20 per cent., which places it among the proteins relatively rich in this amino-acid.

Prolamins have been found in the seeds of all the cereals examined in my laboratory, namely—oats, wheat, maize, rye, barley and sorghum. That this form of protein is characteristic of the seeds of all grasses is rendered improbable by the recent report of Rosenheim and Kajiura,[4] who found none in rice. A detailed statement of their results, however, has not, to my knowledge, yet been published.

3. *Glutelins* constitute a large part of the proteins of all the cereals that have been studied, and possibly occur in seeds of other kinds. These proteins are insoluble in all known neutral solvents, but are easily dissolved by very dilute acids or alkalies. Only one member of this group is known which is accessible to satisfactory investigation. This is the glutenin of wheat which forms nearly one half of the gluten. Owing to the fact that glutenin can be separated from the other components of the seed as a constituent of the gluten, it is possible to make preparations of it of a fair degree of purity.

As the seeds of the other cereals yield no coherent gluten, the protein corresponding to glutenin can not be isolated from them, for the alkaline extracts of these

[2] Chittenden and Mendel, *Journal of Physiology*, XVII., p. 48, 1894.

[3] I propose this name for the group which heretofore has been simply called alcohol-soluble proteins. The name refers to the relatively large proportion of proline and amide nitrogen which they yield on hydrolysis. The English committee on protein nomenclature has very recently proposed to call these proteins gliadins, but as this name has long been used to specifically designate the prolamin obtained from wheat it seems to me important to have a distinctive name for this group.

[4] Rosenheim and Kajiura, *Journal of Physiology*, XXXVI., p. liv, 1908.

seeds are too gummy to filter and the small amount of the preparations that can be obtained is very impure.

Whether glutelins are constituents of other seeds is a question not yet settled. Most seeds, when exhausted with the several neutral solvents, still contain a small amount of protein which can be extracted with alkaline solutions. It has not yet been definitely determined whether these products are residues of the other proteins extracted by the neutral solvents, or are actually different substances. It is quite conceivable that a part of these other proteins may form combinations with other constituents of the seeds which are not soluble in neutral solvents but are extracted by alkalies, and also that a part of the protein is enclosed in tissues which are dissolved by the alkali and the protein then brought into solution. It is also possible that much or all of this protein is the result of a change, whereby a part of the protein originally soluble in neutral solvents is converted into less soluble products, such as those which have been designated as proteans. The quantity of nitrogen which remains in the thoroughly extracted residues of the seeds is small in the case of most seeds other than the cereals, and it is not probable that many of these contain much, if any, protein belonging to the glutelin group.

4. *Albumins* are probably present in *very* small amount in nearly all seeds, and in none of those that I have examined are they present in large amount. The albumin is probably a part of the physiologically active embryo, and resembles the proteins of animal origin in properties, ultimate composition and proportion of the various products of hydrolysis, more closely than do most of the reserve proteins of the endosperm. While the albumins of seeds are like those obtained from animals in the essential properties of solubility in water and coagulability by heat, they differ in their precipitation relations towards strong solutions of inorganic salts.

It is at present almost universally assumed that albumins are not precipitated by adding to their solutions an equal volume of a saturated solution of ammonium sulphate, but this is not the case with all of the albumins from seeds. Many of them are also precipitated by saturating their solutions with sodium chloride or with magnesium sulphate, in which respect they differ from animal albumins.

5. *Proteoses* similar to those of animal origin have been obtained from all the seeds examined, and from some, proteoses closely resembling hetero-, deutero- and proto-proteose were separated. The amount of such proteose is small in all the seeds which have come under my observation, and it is possible that all of this is formed by enzyme action during isolation of the other proteins of the seeds.

There are several groups of proteins which occur in animal tissues, which have not yet been proved to exist in plants. The most important of these are those which contain phosphorus. In the yolk of eggs and in the milk of mammals, a large part of the protein which nourishes the developing animal contains phosphorus which appears to be intimately concerned in the structure of its molecule. No similar phosphorus-containing proteins have been found in seeds, although by analogy such might be expected to occur. It has been asserted that such proteins are found in leguminous seeds, but an examination of the literature will show this assertion to be founded on very little experimental evidence. Czapek, in his "Biochemistry of Plants," describes the proteins of seeds as vitellins which doubtless contain phosphorus. This view, however, has no evidence to support it and is quite incorrect.

The existence of nucleoproteins, that is

of compounds of nucleic acid with protein, is a different question and involves consideration of the chemical nature of these substances as now described. The nucleoproteins are, so far as I know, always described as phosphorus-containing proteins, and the phosphorus seems to be generally considered as a constituent of their molecules. This, of course, is strictly true even if the combination be only that of a base and an acid, but from the standpoint of protein chemistry it makes a great deal of difference whether this union is that of a salt, or one in which the phosphorus-containing groups are in intimate organic combination within the protein molecule. That true nucleic acids exist abundantly in seeds has been demonstrated by investigations made in my laboratory on the wheat embryo. In these investigations a great deal of attention was devoted to the protein compounds of the nucleic acid, but all the evidence obtained indicated very plainly that these were simply protein nucleates, the composition of which depended solely on the conditions prevailing at the time of precipitation. That *similar* combinations exist within the embryo is practically certain, but that any of the combinations actually isolated were *identical* with the combinations that exist in the seed, I consider highly improbable. Whether the nucleoproteins that have been described from animal tissues are more definite and intimate combinations between the nucleic acid and the protein than are the protein nucleates just mentioned, I am not prepared to say, but I think that nucleoproteins deserve more consideration from this point of view than they have received.

Whether, or not, true glycoproteins are contained in seeds, remains to be demonstrated. That a large part of the seed proteins are entirely free from any carbohydrate yielding group, is proved conclusively by the fact that these yield no trace of the Molisch reaction. That those that give the Molisch reaction contain a carbohydrate group as a constituent of their molecule is seriously to be questioned, for it is not possible to obtain even traces of furfurol from them.

If one considers how small an admixture of carbohydrate gives a very strong reaction with the Molisch test, it may well be asked whether this reaction is not sometimes caused by a slight contamination. The possibility of this is so great in the preparations of proteins extracted from seeds containing a great variety of carbohydrates, glucosides and nucleic acids, that conclusions drawn from the results of the Molisch reaction have value only when this turns out negatively.

In plants no representative has yet been found of the group of albuminoids which form in animals so large a part of the skeleton, connective tissues, the skin and its appendages.

Although the nucleated cells of the wheat embryo are rich in nucleic acid which closely resembles in its properties and structure the nucleic acids obtained from the nucleated cells of animals, no substances have yet been found in plants which resemble the protamines which in combination with nucleic acid occur so abundantly in the spermatozoa cells of animals. Such substances are to be sought in the pollen cells of plants, but as yet no attempt has been made to isolate them, owing to the difficulty of obtaining a sufficient supply of material, and the fact that the nucleus of the cell forms so small a part of the whole structure.

PRODUCTS OF HYDROLYSIS OF SEED PROTEINS

Of the known primary products of protein hydrolysis all but one (diamino-trioxydodecanic acid, as yet obtained only from casein) have been isolated from seed

proteins, and there is no indication that any essential difference exists in the general character of the structure of the proteins from these two forms of life. Some of the seed proteins, like some of those from animals, lack one or more of the amino-acids; and zein, from maize, lacks glycocoll, tryptophane and lysine. The crystalline glubolins, which are possibly more definite chemical individuals, have yielded on hydrolysis as complicated a mixture of amino-acids as any of the amorphous preparations. These, therefore, furnish no ground for the assumption that the several proteins, as we now know them, are mixtures of less complex substances.

Of twenty-three different seed proteins which have been hydrolyzed, all have yielded leucine, proline, phenylalanine, aspartic acid, glutaminic acid, tyrosine, histidine, arginine and ammonia. Five have yielded no glycocoll. Two yielded no alanine which could be positively identified, but did yield impure products which left little doubt but that this amino-acid was present. Four yielded no lysine, and one, no tryptophane. Four of these proteins yielded extremely small quantities of cystine, three others, none. The remaining sixteen have not yet been examined for this amino-acid on account of the difficulties encountered in separating small quantities of it. No attempt has yet been made to isolate isoleucine. If this amino-acid is yielded by the seed proteins it will probably be found in the mixture of undetermined substances from the third fraction of the esters, which has not been converted into products suitable to weigh. Glycocoll, lysine and tryptophane are the only amino acids that have been proved lacking in any one of these proteins.

In respect to the quantitative relations of the amino-acids, the fact must not be overlooked that the determinations of many of them are to be regarded only as approximations to the amounts actually yielded by the protein. The determinations of the monamino-acids by Fischer's method are doubtless comparable within certain limits, if sufficient care is exercised in conducting the analysis. The quantities of these amino-acids recovered are unquestionably less than those actually present, for esterification is never complete and the losses incident to the separations by fractional crystallization are not inconsiderable. Under uniform conditions, however, losses are nearly uniform and the figures representing the quantities of amino-acids found give a good idea of differences and similarities between the different proteins. Such figures are in most cases comparable to within perhaps one per cent. of the protein, and probably represent about seventy-five per cent. of the total quantity of the amino-acids which are determined that were originally formed by hydrolysis, providing that these amino-acids are first subjected to two well-conducted esterifications. Most uncertainty attaches to the results obtained for valine and serine, which are separated from associated substances with such difficulty that the determinations of them must be regarded as simply qualitative. Alanine also is difficult to separate in a condition fit for weighing, and no importance is to be attached to differences in the amount of this amino-acid unless these are pronounced.

A very extensive experience, however, with determinations, of arginine, histidine and lysine has convinced me that it is possible to make quantitative determinations of these bases which are very accurate. The results of these determinations can be controlled by comparing the amount of nitrogen contained in the quantities found with that precipitated by phosphotungstic acid under definite conditions which have been worked out in my labora-

tory. The amount of ammonia yielded by hydrolysis can be determined with such accuracy that differences of only a very few hundredths of a per cent. occur between determinations made on different preparations of one and the same protein. These four determinations are the most reliable that we now have for comparing proteins with one another, and make it possible to detect differences between them which would otherwise escape notice.

Glutaminic acid can be determined in most cases with a close approximation to its true amount, but there are some proteins, especially those from leguminous seeds, from which it is not easily obtained. Experience has shown that by the ester method alone about seventy-five per cent. as much glutaminic acid is usually obtained as by direct separation as the hydrochloride. It is possible, therefore, to control to a certain extent the results of direct determinations by comparing them with those obtained on a larger scale by the ester method.

Although the methods available for thus quantitatively analyzing the products of protein hydrolysis leave much to be desired, it must not be forgotten that only recently have we been able to make any comparison whatever of the proportion of these products.

A striking feature of these analyses, to which Professor Chittenden directed attention in his address before this society last January, is that the total quantity of the substances determined falls far short of one hundred per cent. The majority of successful analyses foot up between sixty and seventy per cent., and of this a part is made up of water which has been introduced by hydrolysis. Calculation shows this amount of water to be approximately equivalent to the losses that may be assumed to occur through incomplete esterification and separation of the acids, so that the summation of well-conducted analyses may be taken as representing somewhere near the total quantity made up by all the different substances determined.

Nothing is known of the undetermined residue which forms from twenty-five to thirty-five per cent. of the protein. There is no reason to believe that, in the seed proteins, undetermined carbohydrate forms any part of this, for those proteins which give no Molisch reaction give no higher summation than do those that do.

If the amount of nitrogen contained in the quantities of the amino-acids stated in the analyses is subtracted from the total nitrogen of the protein, it is found that this undetermined nitrogen forms about fourteen per cent. of the undetermined part of the protein. This is a higher proportion of nitrogen than is found in any of the monamino-acids that are known to be yielded by proteins, except glycocoll, alanine, serine and tryptophane, even if the proportion of nitrogen is calculated for them as united with one another in polypeptide union. It is improbable that this undetermined residue is made up of these four amino-acids, and we may expect to find still undiscovered substances among the protein decomposition products.

COMPARISON OF THE PROTEINS OF DIFFERENT SEEDS

The results of this comparative study of the seed proteins shows that no two seeds are alike in respect to their protein constituents. Similar proteins are found only in seeds that are botanically closely related.

The cereals are alike in the proportion and general character of their proteins. The seeds of each of these, with the probable exception of those of rice, contain a small amount of proteose, albumin and globulin, and relatively considerable quantities of prolamin soluble in alcohol, and

of glutelin insoluble in neutral solvents. With the exception of the nearly related wheat and rye, the proteins soluble in alcohol from each of the cereals are distinct substances. Although no certain difference has yet been detected between the gliadin of wheat and of rye, their glutelins are not alike.

The leguminous seeds are similar in the general character of their proteins, but marked differences exist between the proteins of the various groups. Thus *Lupinus, Vicia* and *Phaseolus* present marked differences in their proteins, whereas the proteins of the species of each genus are very much alike. The proteins of *Lupinus luteus* and of *Lupinus angustifolia* differ slightly but in their physical properties are clearly distinguished from any of the other seed proteins. Although similar proteins are obtained from the horse bean, lentil, pea and vetch, these are distinctly different from the proteins obtained from other leguminous seeds. These seeds are not alike, however, in the proportion of their several proteins. The chief protein of *Phaseolus vulgaris* appears to be identical with that of *Phaseolus radiatus,* but the small amount of other protein was found to be different in properties and composition in each of these seeds.

The cow pea (*Vigna*) and soy bean (*Glycine*) contain distinctly different proteins which, however, are similar to but different from those of *Vicia.* The globulins of the seeds of *Corylus* and *Juglans* are much alike, but not identical, while those from *Juglans regia, nigra* and *cinerea,* so far as they have been compared, show no differences. The proteins of other seeds show marked differences, but the botanical relations of these seeds are not such as to permit of further discussion of this subject.

Although the data for generalizations are as yet few, those that are available plainly indicate a close connection between the chemical constitution of the seed proteins and the biological relations of the plants producing them.

That similar differences exist between homologous proteins of different species of animals is becoming evident from the facts which are gradually accumulating, and these strongly suggest a chemical basis for the multitude of diverse forms of animal and vegetable life.

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THE FINANCIAL STATUS OF THE UNIVERSITY PROFESSOR IN GERMANY[1]

ORGANIZATION OF GERMAN UNIVERSITIES

ALL the German universities are government institutions. Like the primary schools and the *gymnasia,* the university is part of the educational system of that German state in which it is located. The professors are officials of the sovereign, and the major part of the university revenues are derived from the state treasury. The government of the university is, in the last resort, in the hands of the sovereign's Minister of Education, who in the constitutional monarchies is responsible to the Chambers, and in Mecklenburg-Schwerin, to the Grand Duke.

The university is thus under the control of the state Parliament and, according to the laws enacted by it, under the immediate supervision of the Minister of Education. The university budget must be passed each year by the Chambers; the creation of a new chair can only be by parliamentary approval. The appointment of professors rests with the sovereign or his minister, and the scheme of instruction together with

[1] Extracted and abridged from Bulletin number two of the Carnegie Foundation for the Advancement of Teaching. See also the issue of SCIENCE for July 24.

the entire educational policy of the university is a matter of state control. As will be seen hereafter, however, this is compatible with a very large measure of professorial freedom and self-government.

As the Minister of Education has charge of the entire school system of the state and is generally also minister of ecclesiastical affairs and several other important branches of government supervision, it is impossible for him to give any minute personal attention to the details of university management. When the annual university budget is before Parliament, or Parliament is discussing any bill affecting the university, he is, of course, in his place as the spokesman of the government, and when university matters must be laid before the sovereign, it is he who is granted an audience by the King or reigning Grand Duke. But while any changes in university policy must be considered by the minister and he is responsible for them, the actual management of university interests generally rests with the permanent officials of the bureau of the ministry which is directly charged with university affairs. The director of that bureau is, therefore, often a person of great influence, Director Althoff, of the Prussian Ministry, having had a power in molding the Prussian universities and, through their example, the universities of the other German states, which is likely to become historic.

At each university the ministry is represented by a commissioner who has charge of the economic side of the academic administration, and acts as the general advisory agent of the government, conducting the correspondence of the university with the ministry. At the Prussian universities, and at the University of Jena and the University of Strassburg this official is called the curator. At the University of Leipzig he is styled the government plenipotentiary; at the University of Tübingen the chancellor, and at the University of Rostock the vice-chancellor, the title of chancellor at Rostock being borne by the reigning Grand Duke. The Ministry of Instruction of Prussia itself attends to the curatorial business at the University of Berlin, assisted by the rector and the university judge.

The curator is a trained jurist or administrative official who has charge of the erection of buildings, the management of the special scholarship funds, and of all those administrative functions, apart from the direct supervision of the instruction, which in the United States are vested in the university president under the general direction of the board of trustees. The tenure of office of the curator is a fairly permanent one.

The titular executive head of a German university is the rector, elected by the full professors (at the University of Göttingen and at the Bavarian universities by the associate professors also) from among their own number for one year, with the approval of the reigning sovereign. The rector represents the university on occasions of ceremony, presides over the senate, is in control of the university officials, of matriculation, and of all meetings and societies of students, and in general transacts the current business of the institution. The rector is never reelected, the office being held in rotation by the full professors. At the universities of Erlangen, Freiberg, Göttingen, Heidelberg and Jena the above duties are performed by a Prorector, and at Giessen and Leipzig by the *Rector Magnificus,* these seven universities having as their titular executive a *Rector Magnificentissimus,* who is at Erlangen the King of Bavaria, at Leipzig the King of Saxony, at Freiburg and Heidelberg the Grand Duke of Baden, at Giessen the Grand Duke

of Hesse, at Jena the Grand Duke of Saxe-Weimar and at Göttingen a prince of the royal house of Prussia.

The distinguishing characteristic of the German university is the power of the full professor (*ordentlicher Professor*). In American universities the professor is simply the highest in rank of an ascending series of teachers. Like the instructors and assistants, he is appointed by a board from which all teaching officials are excluded and he holds his office during the pleasure of that board. Unless he occupies an endowed chair, his salary is generally the result of a bargain with the university president. The professor, indeed, sits as of right in the faculty, which determines the number of courses in the curriculum and regulates the activities of the student body, but seldom is an American faculty asked to propose candidates for vacant professorships.

In Germany the professors are practically the university. The professor, to borrow Anglo-Saxon legal terminology, holds his office as a freehold. Buildings are for the professors to lecture in and subordinate teachers are for the relief of the professors from the less important parts of instruction. The professor decides for himself how he will best serve the students; the body of professors settles such general university matters as in their nature can not be left to individual control. Each university is subject, as are all other institutions in the land, to the control of the sovereign advised by the representatives of his people. But no intermediate non-academic board is interposed between the ultimate authority of the crown and the plenary academic authority of the professors, and the rector, elected by the professors and serving a limited term, has powers analogous to those of the presiding officer of a legislative body; while the powers of an American college president resemble those of the president of a railroad. It must, however, be kept in mind in making any such comparison that the business life of a German university is conducted by the government, through the Minister of Education. The problem of ways and means does not confront the rector and the professors. It is the ever-present demand for money which has gone far to transform the American university organization into a business corporation, as differentiated from a teaching body.

A German university ordinarily consists of the four faculties of philosophy, theology, law and medicine. At the universities of Bonn, Breslau, Strassburg and Tübingen there are both a Roman Catholic theological faculty and a Protestant theological faculty.[2] The universities of Heidelberg and Strassburg have a separate faculty of mathematical and natural science and the University of Tübingen, besides this faculty, has also a faculty of political economy. The University of Munich likewise has a faculty of political economy and its faculty of philosophy is in two separate divisions—classical-historical and mathematical-scientific.[3] The University of Münster is the one German university having but three faculties, lacking that of medicine.

Each of these faculties is composed of the full professors holding chairs therein. The faculty confers the degrees to which its courses lead, gives (except in Bavaria) to promising young scholars the privilege of acting as *Privat-Dozenten* in the university, proposes candidates for vacant professorships, and in general takes such ac-

[2] In the universities of Freiburg, Munich, Münster and Würzburg the theological faculties are Roman Catholic; elsewhere they are Protestant.

[3] In the universities of Freiburg, Münster, Strassburg and Würzburg political economy is studied under the faculty of law.

tion on matters pertaining to instruction within the faculty as it is inappropriate to leave to the individual professor. The faculty is presided over by the dean, elected each year. The election of the dean must usually be confirmed by the Minister of Instruction. The teaching staff consists of full professors (*ordentliche Professoren*), associate professors (*ausserordentliche Professoren*), lecturers below professorial rank (*Privat-Dozenten*), with numerous laboratory assistants and helpers (*Diener*).

At the universities of Erlangen, Jena, Marburg and Tübingen the entire number of full professors, in all the faculties, make up the senate of the university. This is the general legislative body of the institution. In the other universities the senate is composed of the rector and his immediate predecessor, the university judge, the deans of the several faculties and a certain number of professors elected each year by the entire professorial body. The universities of Freiburg, Giessen and Heidelberg, in addition to this smaller representative senate, have also a senate consisting of all the professors, which deals with general disciplinary and administrative matters not referred to the higher body. The universities of Greifswald, Halle, Kiel, Königsberg and Rostock call this full gathering of the professors the Consistory, or the General or Academic Council.

When a vacancy occurs in a professorial chair, the general usage is for the faculty to submit candidates to the reigning sovereign, who either approves one of those proposed or by the exercise of his prerogative appoints a scholar of his own selection. The exact details of these nominations and the frequency with which they are disregarded by the sovereigns differ in the several states. In Prussia, although the faculty concerned has the right to submit three names to the King, the King often makes an independent choice. In Bavaria the faculty sends three names to the senate of the university, and in Württemberg four names, the nominees being arranged in order of preference. The university senate considers the nominations and, having altered them if it sees fit, forwards the list through the minister to the King. It is seldom that either the King of Bavaria or the King of Württemberg does not make the appointment from one of these nominees. In Baden the senate of the university can append a report to the three names, arranged in order of preference, which have been nominated by the appropriate faculty, but can not change the nominations. The grand-ducal Minister of Instruction then makes the selection himself without referring the matter to the Grand Duke, and it is very unusual for another than one of the faculty nominees to be chosen.

When a new chair is created at a university, the final decision whether it is to be a full professorship or an associate one rests with the legislature of the state (or in Mecklenburg-Schwerin with the Grand Duke) at the time of considering the annual budget. Of course, the proposals of the ministry generally receive the assent of the Chambers. A regular professorship is maintained indefinitely, but occasionally personal professorships are created which expire when the occupant of the chair ceases to exercise the functions of a professor. In Prussia, when a chair is to be filled for the first time, the crown does not ask the faculty in which it is to exist for nominations.

The procedure in the selection of associate professors is generally the same as that which prevails in respect to full professors, except that the Minister of Instruction himself acts upon the nominations of

the faculty. The honor of an appointment, coming technically from the reigning sovereign, is usually reserved for the full professor.

The professor, when appointed, is required to announce one public or free lecture course of one hour each week. He must also announce one private or fee lecture course, which may be from two to six hours weekly. These are the only obligations resting upon him. Other fee lecture courses he can announce at will. The professor has entire freedom in arranging his courses and choosing his own lecture subjects. He naturally confines himself to subjects germane to the chair which he occupies and to whose study he has devoted his life, but there is usually nothing in the university regulations which would prevent him from lecturing on any subject he might desire.

The preliminary step necessary to render a scholar eligible for a professorship is for him to secure from a faculty "habilitation," or admission to the privileges of a privat-docent (*venia legendi*). The privat-docent is not an officer of the government, as are the professors, nor does he receive any salary from the university. His "habilitation" means that he is permitted to give lectures in the university to such students as are willing to pay fees therefor, and that the universities will give to students taking such courses the same credit as if the courses were those of a professor.

In Prussia the "habilitation" of the privat-docent rests entirely with the faculty, the ministry of instruction simply signifying through the curator that the royal government has no objection to the candidate. The privat-docent is not required to lecture unless he sees fit, but his name will be dropped from the announcement of lectures if for two successive semesters he fails to give courses. In Bavaria, the King, through the ministry of instruction, grants to a privat-docent the *venia legendi* and he may be removed at will by the royal command. He must conduct each year one course. In Saxony, Württemberg and Mecklenburg-Schwerin the consent of the ministry is necessary for an "habilitation"; in Hesse the rector of the university grants the privilege with the consent of the university senate; and at the University of Jena it is necessary, before a docentship is conferred, to obtain the consent of the Grand Duke of Saxe-Weimar and the reigning Dukes of Saxe-Meiningen, Saxe-Altenburg and Saxe-Coburg-Gotha. In the Roman Catholic theological faculties an "habilitation" must receive the sanction of the bishop of the diocese.

The requirements for an "habilitation" have been constantly rising in recent years, and the average age at which a scholar acquires this privilege is well above thirty. Although instances of large fees by privat-docents have existed, the largest practical possibility is from four to five hundred dollars a year. The average income is certainly not much above two hundred dollars. Students have a strong tendency to pay their fees for the lectures of the better known professors, and the situation to-day of the privat-docent who does not possess a private income or is without the backing of wealthy relatives remains the same as when Herr Teufelsdröckh climbed his many flights of stairs at the University of Weissnichtwo. Nor is there any sure hope of a professorship to solace their years of financial barrenness. A chair in the faculty may never come at all; even if it is attained, the period of waiting is beyond calculation. Probably the situation is more difficult than it was when Kant remained a privat-docent at the University of Jena until he was forty-six.

When a man, however, has been commissioned a full professor or an associate professor in a German university, he has attained a financial status which, although it varies widely, is certain to be well within the margin of comfortable living. His income is a total usually composed of (1) a salary attached to his professorship, (2) a personal supplement, (3) a residence or a residence indemnity, (4) all or part of the fees paid by students for his courses and (5) a part of the more general fees paid by students to the university (faculty fees, examination fees, diploma fees, etc.). The receipts from fees are a very important proportion of the total income of the professor, often far exceeding all the other sources of income combined.

The Carnegie Foundation for the Advancement of Teaching has secured from the governments of the Kings of Prussia, of Saxony and of Württemberg, from the government of the Grand Duke of Baden and from the university authorities, a statement of the individual incomes in 1906, from each of the above-mentioned five sources, of the full professors and the salaried associate professors (*etatsmässig ausserordentliche Professoren*) in thirteen universities. These thirteen universities are the ten Prussian universities of Berlin, Bonn, Breslau, Göttingen, Greifswald, Halle, Kiel, Königsberg, Marburg and Münster, the University of Leipzig (Kingdom of Saxony), the University of Tübingen (Kingdom of Württemberg) and the University of Freiburg (Grand Duchy of Baden).

It is only upon such statements of individual incomes that any final account of the financial status of a professor can rest, and the Carnegie Foundation takes this opportunity to express its thanks for the courteous and efficient cooperation of the governments of the German sovereigns and of the German universities which has enabled the foundation to secure these detailed individual incomes. It is to be regretted that they can not be published, but it was not thought wise to present the facts concerning individuals even though no names should be stated. Only averages will be given.

To the statement of income directly resulting from the teaching is added in each case on our lists a statement of income from other governmental employments. This secondary income varies in its nature from what is really a civil-list pension from the sovereign to the professor to a distinct outside salary for outside work, such as the professor might earn by private tutoring or the practise of a profession. These additions to income will not be considered in any of the text or tables that follow unless a special statement to that effect is made.

GOVERNMENT SALARY SCHEDULES IN THE UNIVERSITIES OF THE DIFFERENT GERMAN STATES

Below will be found the salary schedules for full professors which have been adopted by the different German governments. These salaries are simply the guarantees which the government gives to the professor, and constitute only a small proportion of the total professorial income. Following the account of these government appropriations to the professorial chairs will be a table giving the total academic income of the full professor in German universities, and some discussion thereon. It is with these later figures that the salary of the American professor must be compared.

Kingdom of Prussia.—In 1897 the royal government presented to the professors in all the Prussian universities a contract and invited their signatures. According to this contract the professor was to give up to the kingdom one half of

all the fees in excess of 3,000 Marks ($713), except at the University of Berlin, where the surrender was one half of the fees above 4,500 Marks ($1,069). This calculation of 3,000 and 4,500 Marks was not to include the commission of the "Quaestus" for collecting the fees. The professor was to receive these sums of 3,000 and 4,500 Marks net. Professors appointed in 1897 and afterwards were required to sign this contract. In exchange the royal government promised to arrange the salary schedule so that there should be an increase in the professor's salary proportional to his length of service, and guaranteed a minimum income of fees of 800 Marks ($190) from lecture fees, examination fees, and promotion fees, to all of the full professors and the associate professors alike. Many professors whose fees were greatly in excess of 3,000 Marks, or 4,500 Marks at the University of Berlin, declined to accept the government's invitation. According to Professor Biermer, only 361 out of the 738 *etatsmässig* professors in the Prussian universities agreed at once to the proposal. For the others there was thus no regular increase of salary as their period of service lengthened. But many of the professors who at first refused have since given their adhesion to these regulations, and as all of the appointees since 1897 are under its provisions, the plan may now be considered as the normal arrangement in the Prussian universities.

Under the salary schedule thus in force since 1897, the theory is that a full professor begins his service with an annual government salary of $950; at the University of Berlin $1,040. Thereafter there is an increase of $95 every four years until in twenty years a maximum of $1,425 is reached; at the University of Berlin a maximum of $1,711 in twenty-four years. At the discretion of the royal Ministry of Public Instruction the maximum may be raised in special instances to $1,853—at the University of Berlin to $2,233. With the approval of the King the respective maxima may go even higher, and at the University of Berlin it is now $3,563.

Associate professors in the Prussian universities begin usually at an annual salary of $475—at the University of Berlin $570. Their salaries are advanced in the same manner by $95 every four years until the maximum of $950 is reached in twenty years—at the University of Berlin $1,140 in twenty-five years. An associate professor, like the full professor, may likewise receive a special guarantee of fees, or a special salary supplement.

In Prussia each full and salaried associate professor receives an additional sum of money each year as a "residence indemnity," granted quite generally to all the higher civil servants of the King, because of the greater cost of living in the cities. The Universities of Berlin and of Breslau (which has recently been raised to the same class as Berlin) fix this residence indemnity at $214 annually. At the Universities of Bonn, Halle, Königsberg and Kiel, it is $157, and at the Universities of Göttingen, Greifswald and Marburg, it is $128.

Kingdom of Bavaria.—About fifteen years ago the Bavarian government adopted a new salary scale for the university professors, whereby their incomes are considerably augmented. A full professor now commences with a government salary of $1,083 (4,560 M.). At the end of each of three periods of five years $85 (360 M.) are added to the salary, and thereafter the increment is $42 (180 M.) at the end of each period of five years. An associate professor usually commences with a government salary of $756 (3,180 M.), receiving the same increases

as the full professor. The salary scale is as follows:

	Full Professor	Associate Professor
To commence	$1,083 (4,560 M.)	$756 (3,180 M.)
After 5 years	1,168 (4,920 M.)	841 (3,540 M.)
After 10 years	1,255 (5,280 M.)	926 (3,900 M.)
After 15 years	1,340 (5,640 M.)	1,013 (4,260 M.)
After 20 years	1,383 (5,820 M.)	1,055 (4,440 M.)
After 25 years	1,426 (6,000 M.)	1,098 (4,620 M.)
After 30 years	1,470 (6,180 M.)	1,140 (4,800 M.)
After 35 years	1,512 (6,360 M.)	1,183 (4,980 M.)
After 40 years	1,555 (6,540 M.)	1,227 (5,160 M.)
After 45 years	1,598 (6,720 M.)	1,264 (5,340 M.)
After 50 years	1,640 (6,900 M.)	1,312 (5,520 M.)

In addition to the above there is also the residence indemnity—called in Bavaria "salary supplement" of $127 (540 M.) for full professors and $99 (420 M.) for associate professors. Besides this, there is a further residence indemnity—called "local supplement" in Bavaria—which was added a few years ago because of the increased cost of living. This amounts to $64 (270 M.) at the Universities of Munich and of Würzburg—in cities of the "first class"—and to $54 (225 M.) at the University of Erlangen—in a city of the "second class." In case the fees of a professor amount to more than $286 (1,200 M.) in one year his residence indemnities for that year are cancelled. If the fees do not amount to $286, so much of the residence indemnities is paid to the professor as is necessary to bring the total up to $286.

Grand Duchy of Hesse.—A full professor at the University of Giessen begins his service with an annual government salary of $1,069. This is increased every four years by $95 until in twenty years the maximum of $1,544 is attained.

The associate professor is appointed at an annual salary of $595 (2,500 M.) and after each period of four years' service $71 (300 M.) is added annually. The maximum is $950 a year. Very recently the grand-ducal government has authorized a residence indemnity. This is calculated on the basis of eight per centum of the maximum salary, and is therefore $123 (520 M.) a year for the full professor and $75 (320 M.) for the associate professor. There is in addition a special fund, amounting at present to $2,350 a year, at the disposal of the Grand Duke's Minister of the Interior for the purpose of adding supplements to individual salaries.

Grand Duchy of Saxe-Weimar.—Until 1902 government salaries at the University of Jena were very meager, the professors being released from all payments of taxes, however, whether grand-ducal or communal. In 1902 there was a salary reform, a schedule being introduced on the Prussian model, optional as regarded the holders of professorial chairs at that time. About one fourth of the professors adhered to the old arrangement. Those who accepted the change and all professors appointed since are liable like other subjects to taxes, all of the grand-ducal taxes so collected and one third of the communal taxes going, however, into the treasury of the university. In return for this the full professor begins his service at an annual government salary of $950, which is raised every four years, until in twenty years he receives $1,425. The associate professor receives a similar increase in the same periods, his annual salary beginning at $475 and reaching in twenty years $950. A part of this increase in the university salary schedules was made possible by the income of the Karl Zeiss Foundation, which is now annually $7,130. The grand-ducal government of Saxe-Weimar, the ducal governments of Saxe-Meiningen and Saxe-Altenburg, and the Gotha duchy of the reigning Duke of Saxe-Coburg-Gotha also contributed a similar amount. These four governments jointly have royal rights over the university.

Grand Duchy of Mecklenburg-Schwerin.

—The full professors at the University of Rostock begin with a government salary of $998 (4,200 M.) and receive a $95 increase at the end of the second and fourth years of service. Thereafter there is an increase of $95 every four years until at the end of twenty years of service the maximum of $1,568 is reached.

The associate professor at the University of Rostock commences with a salary of $570. After three years there is an increase of $71, and thereafter the like increase at the end of each four years. The maximum government salary of $856 is attained at the end of fifteen years' service.

At present, the average government salary for full professors at the University of Rostock is $1,321. By faculties, the averages are as follows: theology, $1,473; law, $1,654; medicine, $1,179; philosophy, $1,249. The averages in theology and law are much above the similar figures for Prussia. The associate professors in the theological and in the law faculty (there is but one each), and the honorary professor of the medical faculty, receive government salaries of $641. The average for associate professors in the philosophical faculty is $615.

Kingdom of Württemberg.—At the University of Tübingen the full professor usually commences at $950 government salary annually, and is advanced at the end of every three years $119. Four such three-year promotions are allowed. Salary supplements are granted by the royal Minister of Public Education and sometimes these supplements equal two thirds of the regular government salary. A newly appointed professor may begin his service with one of these large supplements.

The associate professors are appointed at $570 a year, and every three years receive an increase in salary of $71. There may be five of these advances. There are now but two associate professors at the University of Tübingen receiving personal salary supplements from the royal government, promotion to the rank of full professors being the usual reward for distinguished service.

The University of Leipzig (Kingdom of Saxony) has no government salary schedule, the salary being arranged in each case between the professor and the royal Minister of Education. The grand-ducal Minister of Instruction makes a similar arrangement with the professors in the Baden Universities of Freiburg and Heidelberg, and at the University of Strassburg each professor's government salary is likewise the result of negotiation with the Minister of Instruction of the Reichsland.

INCOMES OF PROFESSORS

Table XI. gives the facts concerning the total professorial incomes of the full professors in the German universities. The incomes range from $1,000 a year to over $10,000, with three professors receiving incomes above that figure. Up to $10,000 the incomes have been segregated, as a convenient division, into two-hundred-dollar groups.

This table shows that a fourth of the incomes are below $2,100, while, on the other hand, a fourth are over $3,200, a trifle short of a half being over $2,500. The most frequent income is one between $1,600 and $2,000. The average is $2,800, but this does not represent the typical income, because, like most averages in financial statistics, it is a result of the compounding of many moderate deviations downward with fewer, but larger, deviations upward.

One of the most significant facts disclosed by this table is the wide variability of the professorial income. On account of the salary schedules announced by their respective governments for all except four

of the German universities, these universities give at a superficial glance an aspect of uniformity and rigidity. The truth is far otherwise. There is a much greater variation in income to suit individual merit than is the case with comparable institutions in the United States. It will be seen from Table XI. that in Germany the best paid full professor receives ten times as much as the least paid professor and that the highest income from professorial teaching is more than four times the median income. This is not the case in America.

This adjustment of the financial returns of German professors according to the capability of each individual is due primarily to variations of income within the same institution. Of course, as in the United States, there is a considerable variation among the institutions themselves. Owing to the different fiscal policies of the different governments and the different provisions made by the same government for universities in more important locations, and also on account of the difference in fees due to the size of the student body, there will be found German universities in which the average income of the full professor is from twice to three times the average income in some other university. The wide range of the academic income of professors in the same institution is hardly known in America. In any large German faculty some full professor will generally be found who receives for teaching an income from two to five times as large as some of his colleagues. These larger incomes are due to special allowances from the government, to extra university perquisites, and to fees from the large body of students attracted by a superior reputation. Both the German and the American universities pay for merit. This is understood when a man in either country is made a full professor. The distinction

TABLE XI

Incomes received for Teaching by Full Professors in German Universities

Amount of Annual Income	Total Number of Professors receiving said Income	Percentage of Professors receiving said Income
$1,000–1,199	5	.7
1,200–1,399	17	2.5
1,400–1,599	38	5.6
1,600–1,799	64	9.4
1,800–1,999	71	10.4
2,000–2,199	82	12.1
2,200–2,399	51	7.5
2,400–2,599	52	7.6
2,600–2,799	54	7.9
2,800–2,999	53	7.8
3,000–3,199	24	3.5
3,200–3,399	21	3.1
3,400–3,599	17	2.5
3,600–3,799	16	2.4
3,800–3,999	16	2.4
4,000–4,199	11	1.6
4,200–4,399	9	1.3
4,400–4,599	13	1.9
4,600–4,799	9	1.3
4,800–4,999	6	.9
5,000–5,199	5	.5
5,200–5,399	7	1.0
5,400–5,599	2	.3
5,600–5,799	1	.1
5,800–5,999	3	.4
6,000–6,199	6	.9
6,200–6,399	3	.4
6,400–6,599	3	.4
6,600–6,799	..	..
6,800–6,999	2	.3
7,000–7,199	2	.3
7,200–7,399	2	.3
7,400–7,599	1	.1
7,600–7,799	2	.3
7,800–7,999	1	.1
8,000–8,199	1	.1
8,200–8,399	2	.3
8,400–8,599	..	..
8,600–8,799	..	..
8,800–8,999	1	.1
9,000–9,199	..	..
9,200–9,399	2	.3
9,400–9,599	1	.1
9,600–9,799	1	.1
9,800–9,999[a]	1	.1

[a] Three professors received incomes of over $10,000.

between the two countries is that the German universities pay an unusual amount for unusual merit. In America, on the contrary, the unusual man fares no better than his colleagues of mediocre ability.

Table XII. gives the facts of Table XI., distributing the income among the four faculties of each university.[5] It is evident at a glance that professors of law receive most, and professors of theology least.[6] Professors of medicine occupy the second place.

The associate (*ausserordentliche*) professors in German universities are of two kinds, the *etatsmässig ausserordentliche* professors and the *nicht-etatsmässig ausserordentliche* professors. The former is the class meant when associate professors are spoken of without any qualifying expression. The latter class is about one fourth of the entire number, varying in different universities from ten to eighty per cent. They enjoy the title of associate professor, but the title is not accompanied by an appointment from the government, nor do these associate professors draw the government salary appropriate to their rank. They are either teachers who have practically the financial status of privat-docents but have been given the higher title on account of merit or long service, or they are men who for various reasons are exempt from the responsibilities and the rewards which normally attach to the professorial office. The following statements will deal solely with the *etatsmässig* associate professors.

In the thirteen universities which have been carefully studied, the number of these professors is about three sevenths of the number of the full professors. Four tenths of the associate professors are in receipt of professorial incomes of from $1,000 to $1,400; one fourth of them receive less than $900; half of them receive over $1,200; and one fourth receive more than $1,700. The incomes below $600 and those above $2,400 number about the same. The typical income is one from $1,000 to $1,200. Ninety-six per cent. of the incomes lie between $900 and $2,400, and eighty-seven per cent. between $600 and $2,000, and although this indicates a very large variability of income, it is not as great a variability as was found in the case of full professors. The average income of an associate professor is a trifle over $1,300.

The professorial incomes which have been given must, of course, be interpreted in terms of the cost of living. To compare this cost of living with the similar cost for an American university professor is difficult. The Carnegie Foundation has endeavored to obtain the cost of provisions, servant-wages, and house rent in the German university cities, in order to be able to institute a comparison with a similar investigation conducted in America. The cost of foodstuffs in Germany, especially since the new Imperial Tariff Act, is higher than in the United States; the wages of servants, on the other hand, are very much lower. House rent is lower than in America, although not nearly as much lower as servant hire. For the latter item there is, as in the United States, a great difference between different localities. Marburg and Berlin can no more be considered together in respect to the necessary scale of professorial expenditure than can Charlottesville and New York. Furthermore, in Germany no more than in America is it possible to estimate what a professor and a

[5] Faculties of natural science are counted as faculties of philosophy in this table and throughout this bulletin.

[6] It must be remembered that at eight German universities there are Roman Catholic faculties of theology, which consist largely, if not exclusively, of celibate ecclesiastics.

professor's family need to spend. Individuals and families vary in their necessities and standards of living as much in university circles as in other circumstances of life. Probably, however, it will be a fair approximation to the facts if we estimate the cost of living in the localities of the United States in which universities most comparable to those of Germany are situated, taking all of these variables into account, as one and a half times greater than in Germany.

Compared with other classes in the community, the German university professor is still better off than his American colleague. He ranks financially with very important legal and administrative officers; and no principal of a normal school or head of a city system of schools approaches in income from educational work the income received by a considerable percentage of university professors. The German governments pay teachers in the elementary schools well, and the teachers in the secondary schools especially well, but the full professor in a university receives over four times as much as the former and over twice as much as the latter class. The financial status of the university professor in Germany is thus seen to be at the top in the educational world and on a level with all except the nobility and the more successful of business men. It is unnecessary to revert to the dissimilar position of the university professor in America. And human nature being what it is, the higher relative prosperity of the German professor probably seems as important to him as his higher absolute prosperity.

THE OKLAHOMA GEOLOGICAL SURVEY

The Oklahoma Geological Survey was established by the act of the first legislature of the state of Oklahoma. The sum of $15,000 was appropriated. The law provides that until suitable laboratories, libraries and testing apparatus are provided by the state the survey shall be located at the state university.

The commission, consisting of the governor, the superintendent of public instruction and the president of the state university, met for organization, July 25, 1908. A director was appointed and instructed to begin at once the preparation of reports on building stone, road material and oil and gas.

A number of parties were at once organized and active field work pursued for six weeks. L. L. Hutchison, assistant director of the survey, had charge of a party in the oil fields in the vicinity of Tulsa and Muskogee. Members of this party were: W. J. Cross, B. C. Belt, A. C. Reeds and T. R. Corr. Dr. D. W. Ohern had charge of a party in the northern part of the state engaged in studying building stone, oil and gas and Portland cement rock. H. A. Everest, E. Z. Carpenter and H. G. Powell were in this party. Pierce Larkin made a reconaissance of the Cretaceous deposit along Red River from Ardmore east to the Arkansas line. Dr. J. W. Beede, of Indiana University, studied the Pennsylvania-Permian contact in the northern part of the state. Chester A. Reeds and Key Wolf studied the economic products of the Arbuckle mountains. Gaylord Nelson collected data on the lead, zinc and tripoli deposits in the northeastern part of the state. G. W. Kneisly visited the granite quarries in the Wichita and Arbuckle mountains. Frank A. Herald and Chester C. Clark made a reconnaissance of the gypsum region in western Oklahoma looking for deposits of gypsite.

A geologic map of Oklahoma is being prepared, and it is the intention to publish preliminary reports on the oil and gas regions, the available road material, and the building stone of the state and a report on the economic resources of the Arbuckle mountains.

Chas. N. Gould

THE INTERNATIONAL CONGRESS ON TUBERCULOSIS

The program of the congress in session this week in the new National Museum, Washington, is as follows:

September 21–October 12—Exhibition.

September 28–October 3—Section meetings.

September 24–October 9—Special lectures (Washington, Baltimore, Philadelphia, New York and Boston).

Special days at the exhibition:

Monday, September 21, 8 P.M.—Formal opening.

Saturday, September 26—Women's clubs and allied organizations.

Sunday, September 27—Fraternal organizations.

Sunday, October 4—Labor unions.

Tuesday, October 6—Social and charity workers.

Thursday, October 8—Religious organizations.

Saturday, October 10—School children and teachers.

Monday, September 28, 11 A.M. (Assembly Hall, new National Museum)—Official welcome of delegates.

2:30 P.M.—Opening session of Sections I., II., III. and VI.

3:00 P.M.—Opening session of Section IV. (no sessions of Sections V. and VII. on Monday).

8:00 P.M. (Assembly Hall)—Lecture by Dr. A. A. Wladimiroff, of Russia, on "The Biology of the Tubercle Bacillus."

8:30–11:00 P.M.—Reception to visitors at the Corcoran Art Gallery.

Tuesday, September 29—Opening sessions of Sections V. and VII. and sessions of other sections continued.

2:30 P.M.—Section meetings continued.

8:00 P.M. (Assembly Hall)—Lecture by Dr. Arthur Newsholme, of London, Medical Officer to the Local Government Board of England, London, on "The Causes of the Past Decline of Tuberculosis, and the Light thrown by History on Preventive Measures for the Immediate Future."

Wednesday, September 30–Saturday, October 3—Section meetings continued.

September 30, 8:00 P.M. (Assembly Hall)—Lecture by Dr. Maurice Letulle and M. Augustin Rey, of Paris, on "La lutte contre la tuberculose dans les grandes villes par l'habitation: méthodes scientifiques et modernes pour construction" (The campaign against tuberculosis in large cities by scientific methods in the construction of habitations). Illustrated.

Thursday, October 1, 8:00 P.M. (Chamber of Commerce, corner of Twelfth and F Streets)—Dr. R. W. Philip, of Edinburgh, has been invited by the Chamber of Commerce of Washington to deliver his Boston address, "The Anti-tuberculosis Program; Coordination of Preventive Measures."

Friday, October 2, 2:30 P.M.—Reception by President Roosevelt to the delegates at the White House.

8:00 P.M. (new National Museum)—Lecture by Professor N. Ph. Tendeloo, Leyden, Holland, on "Collateral Tuberculosis Inflammation."

Saturday, October 3, 11:00 A.M. (Assembly Hall, new National Museum)—General Session of the Sections.

8:00 P.M. (Assembly Hall, New National Museum)—Lecture by Professor Bernard Bang, of Copenhagen, Denmark, on "Studies in Tuberculosis in Domestic Animals and what we may learn regarding Human Tuberculosis."

ORGANIZATION OF A BIOLOGICAL BOARD

AT the Chicago meeting of the board of trustees of the Marine Biological Laboratory at Woods Hole, measures were taken to institute a central board composed of representatives from all those stations engaged in marine work. Through a committee composed of the undersigned, a circular letter was addressed to all those stations believed to be engaged in the study of marine life. Responses were prompt and expressed a cordial endorsement of the plan. With one or two exceptions in which the directors did not feel that the character of the work would justify cooperation, all expressed their willingness to participate. Since the list was completed, and the report of the committee was ratified at the summer meeting of the board of directors, Woods Hole, one or two other stations have been heard from as now in process of development. It is contemplated that these and others, as they may be organized, will take their places on the board by invitation. The board as now organized consists of the following:

Marine Biological Laboratory, Woods Hole—Dr. F. R. Lillie, director, University of Chicago.

Biological Laboratory, Cold Spring Harbor, Long Island, N. Y.—Professor Henry S. Pratt, Haverford College, Haverford, Pa.

Biological Laboratory, Harpswell, Maine—Dr. J. S. Kingsley, director, Tufts College, Medford, Mass. Professor H. V. Neal, Galesburg, Ill., will act as substitute in the absence of Dr. Kingsley.

Rhode Island Fish Commission—Dr. A. D. Mead, director, Brown University, Providence, R. I.

The Wistar Institute, Philadelphia—Dr. J. M. Greenman, director.

Tortugas Station of the Carnegie Institution, Tortugas, Florida—Dr. A. G. Mayer, Maplewood, N. J.

Biological Station of the University of California, La Jolla, California—Dr. W. E. Ritter, director, University of California.

Biological Station of the Leland Stanford Jr. University, Palo Alto, Cal.—Dr. Harold Heath, Leland Stanford Jr. University.

U. S. Fish Commission, Woods Hole, Mass.—Dr. B. W. Evermann, Department of Commerce and Labor, Washington, D. C.

The Cinchona Station of the New York Botanical Garden, Jamaica, W. I.—Dr. N. L. Britton, director, New York Botanical Garden, Bronx Park, N. Y.

The Bermuda Biological Station of Harvard University, Cambridge, Mass.—Dr. E. L. Mark, director, Cambridge, Mass.

The Biological Stations of Canada.

The Pacific Coast Station, Nanaimo, B. C.—Professor E. E. Prince, director, Department of Marine and Fisheries, Ottawa.

The Great Lakes Station, Georgian Bay, Ontario—Dr. R. Ramsay Wright, director, University of Toronto, Toronto, Ont.

The Atlantic Coast Station, St. Andrews, N. B.—Dr. D. P. Penhallow, director, McGill University, Montreal, P. Q.

The various representatives of the board, as thus announced, are requested to accept this announcement as a notice of their appointment. The first meeting of the board for organization and such other business as may require to be transacted, will be called at a later date, probably at the time of the Baltimore meeting in convocation week, and of this due notice will be given.

D. P. Penhallow, *Chairman*
F. R. Lillie

SCIENTIFIC NOTES AND NEWS

The Winnipeg meeting of the British Association for the Advancement of Science, under the presidency of Professor J. J. Thomson, of Cambridge, will open on Wednesday, August 25, 1909. The meeting of the association in 1910 will be at Sheffield, and in 1911 at Portsmouth.

In connection with the meeting of the British Association, the University of Dublin conferred the following honorary degrees: *D.Sc.*, Mr. Francis Darwin, F.R.S., Sir David Gill, K.C.B., F.R.S., Dr. William Napier Shaw, F.R.S., Captain Henry George Lyons, F.R.S., Professor Horace Lamb, F.R.S., Professor Charles Scott Sherrington, F.R.S., Professor Ernest Rutherford, F.R.S., Professor Archibald Byron Macallum, F.R.S., Dr. Albert Kossel, and Dr. Ambrose Arnold William Hubrecht; *M.D.*, Sir Thomas Lauder Brunton, Bart., F.R.S.; *LL.D.*, Sir James Augustus Henry Murray.

At the meeting of the Paris Academy of Sciences on September 14, M. Jean Becquerel communicated the following clause from the will of his father M. Henri Becquerel: "I bequeath to the Academy of Sciences the sum of 100,000 fr. in memory of my grandfather and father, who were, like myself, members of your academy. I leave to it the responsibility of determining the best use which it can make of the interest on this capital, whether by creating an endowment or prize, or by distributing this income in a manner calculated to encourage the progress of science." The grandfather referred to was Antoine César Becquerel, distinguished for his work in electrochemistry. The father was Alexander Edmund Becquerel, distinguished for his work in light, electricity and magnetism. Louis Alfred Becquerel, the eldest son of A. C. Becquerel made valuable contributions to medical science. The scientific eminence of the family has thus been continued through four generations.

Professor Thomas H. Macbride, of the University of Iowa, has been appointed by Governor Cummins as chairman of the Iowa Forestry Commission, the other members being Professor L. H. Pammel, Mr. Eugene Secor, Mr. William Louden, Mr. I. M. Earle and Mr. Wesley Green. This commission, which grew out of the recent conference of governors on the conservation of natural resources, will cooperate with the national or-

ganization in the promotion of scientific and practical forestry.

DR. H. W. WILEY has received notice of his election as honorary member of the Physico-Chemical Academy of Italy for his services to science and humanity. He has also been awarded the medal of the first class by the same academy.

PROFESSOR VON LEYDEN, of Berlin, has been elected honorary president, Professor Czerny, of Heidelberg, president, and Professors Pierre Marie, of Paris, and Fibiger, of Copenhagen, vice-presidents, of the International Association for the Investigation of Cancer, founded at Berlin on May 23.

PRESIDENT IRA REMSEN, of the Johns Hopkins University, made the address at the opening of the College of the City of New York.

THE Huxley lecture will be delivered at Charing Cross Hospital on October 1, by Sir Patrick Manson. The subject will be "Recent advances in science and their bearing on medicine and surgery."

PROFESSOR W. M. DAVIS, visiting professor from Harvard University at the University of Berlin for the year 1908–9, will give his lectures in the first semester, instead of in the second, as previously announced.

DR. M. F. GUYER, professor of zoology at the University of Cincinnati, who is in Europe on a leave of absence, has been invited to deliver a series of lectures in the University of Aberdeen.

DR. BERNHARD FISCHER, docent at Bonn, has been appointed director of the Pathological Institute of the Senckenberg Society at Frankfort.

THE *Electrical World* states that Dr. Edward P. Hyde, now of the Bureau of Standards, after October 1, will organize and direct a department of physical research under the auspices of and at the expense of the National Electric Lamp Association. Dr. Hyde and his staff will, it is announced by the association, operate the new department with entire freedom from commercial suggestion and with the same frank publicity which has characterized his work at the Bureau of Standards.

A MONUMENT in honor of Hermann von Wissmann, the German African explorer, has been unveiled at Lauterberg, in the Hartz.

DR. MORRIS M. GIBBS, of Kalamazoo, Mich., a student of ornithology and allied sciences and for years a frequent contributor to scientific literature, died at his home on September 18.

GENERAL J. F. NERY DELGADO, for many years director of the Geological Survey of Portugal, died at Figueira-da-Foz on August 3, in his sixty-fourth year.

CAV. ENRICO DE NICOLIS died at Verona, Italy, on July 4. He had published many important papers upon the geology of northern Italy.

MESSRS. J. P. AULT and C. C. STEWART, working under the auspices of the department of terrestrial magnetism of the Carnegie Institution of Washington, made a record canoe trip during the past summer, starting out from Prince Albert and Cumberland House in the Province Saskatchewan, Canada, and extending up to the sixtieth parallel, via Pelican Lake, Reindeer Lake, Lac Du Brochet, Sandy Lake, Husky Portage and Canoe Limit (about one and one half miles north of the sixtieth parallel). The trip embraced sixty-eight days during June, July and August; 1,600 miles were covered by canoe and 71 portages varying from 100 yards to two miles were made. The party encountered various unique experiences and penetrated a region inhabited by Eskimos, but rarely visited by white man. A complete series of magnetic observations was obtained along the entire trip.

DR. J. WALTER FEWKES, of the Bureau of American Ethnology of the Smithsonian Institution, has been assigned to continue the work of excavation, preservation and repair of the cliff dwellings and other prehistoric ruins in the Mesa Verde National Park, Colorado, under the special allotment for that purpose by congress through the Interior Department. The Mesa Verde National Park

was created by act of Congress approved June 29, 1906. It is situated on the border of the Montezuma Valley, just south of the ancient Montezuma road, and contains some of the best preserved relics of the prehistoric cliff dwellers in the country. During last spring Dr. Fewkes had charge of the excavation and repair of Spruce-tree House, one of the largest and most typical cliff dwellings of the park. A wall forming the front of this village, formerly hidden under fallen débris, was brought to light and repaired throughout its whole length. The former plazas were restored to their original condition. In the course of the work 120 rooms were cleaned out and repaired. Eight of these, which are circular in form, were found to be ceremonial in nature. They were excavated to their floors and their architectural features revealed. The roofs of two of these circular rooms were restored, following aboriginal lines of construction. Provision was made to prevent destruction of the walls by freshets or water falling on them from the rim of the overhanging cliff. In order to increase the attractiveness of this ruin to visitors, explanatory labels were placed on the more important rooms.

According to the Simla correspondent of the London *Times*, Dr. Sven Hedin sums up the results of his explorations as follows: My great discoveries are, first, the true sources of the Brahmaputra and Indus, and the genetic source of the Sutlej east of Mansorawar Lake; secondly, the exploration of Bongba, which I traversed twice by different routes. But the greatest of all is the discovery of that continuous mountain chain which, taken as a whole, is the most massive range on the crust of the earth, its average height above sea level being greater than that of the Himalayas. Its peaks are 4,000 feet to 5,000 feet lower than Everest, but its passes average 3,000 feet higher than the Himalayan passes. The eastern and western parts were known before, but the central and highest part is in Bongba, which was previously unexplored. Not a tree or a bush covers it; there are no deep-cut valleys, as in the Himalayas, for rain is scanty. The absolute heights remain to be calculated from observations made on the ten passes which I crossed.

The bison range in the Flathead Indian Reservation in Montana, to establish which congress at its last session appropriated $40,000, has been selected. The location of the range is the one recommended by Professor Morton J. Elrod, of the University of Montana, after he had carefully examined several parts of the country. It lies directly north of the Jocko River near the towns of Ravalli and Jocko. Approximately 12,800 acres are embraced in the tract, which will be fenced in a substantial manner under the direction of the engineering department of the United States Forest Service. Of the $40,000 appropriated only $10,000 will be available for fencing the range and constructing the shelter sheds and other buildings necessary for the proper maintenance and care of the bison. The remaining $30,000 will be paid to the owners of the land, many of whom are Indians. Funds for the purchase of bison are being raised under the auspices of the American Bison Society, which was largely instrumental in securing the appropriation. The first person to spend actual money in the effort to preserve the American bison from total extinction was the late Austin Corbin, who many years ago fenced some 6,000 acres at Blue Mountain Park, New Hampshire, and secured a herd of bison. The Corbin herd became in course of time the inspiration of the national movement which is now furthered by the American Bison Society. This society, of which President Roosevelt is honorary president, and William T. Hornaday, director of the New York Zoological Park, is president, was founded in 1904, and the Montana bison range is directly the result of its efforts. Details of the management of the herd in the new national bison range will be worked out as soon as the herd is purchased, when the construction work on fences and buildings will also be begun.

At the recent third International Congress of Philosophy, held at Heidelberg, it was decided that the fourth congress will take place in 1912 at Bologna.

WE learn from *Nature* that the following arrangements have been made for the opening of the winter session of certain of the British medical schools. At Guy's Hospital (in connection with the Physical Society), Sir R. Douglas Powell will deliver an address on October 8 entitled "Just Procedure of Medicine"; Dr. Charles Slater is to speak on October 1 at St. George's Hospital on "The Laboratory in Medical Education and Practise"; on the same date an address will be delivered at the Middlesex Hospital by Dr. A. M. Kellas; at King's College Hospital Professor Alexander MacAlister, F.R.S., will deliver an address on October 1; Sir Edward Fry, F.R.S., is to speak at University College Hospital on October 2. At St. Mary's Hospital, on October 1, an address is to be given by Sir John Broadbent; Dr. Harrington Sainsbury is to speak on the same day at the London School of Medicine for Women; at the West London Postgraduate College an address is to be given on October 13 by Sir R. Douglas Powell; Dr. R. Jones is to speak on "Insanity, Wit and Humor" on October 1 at the Polyclinic; at the Northeast London Postgraduate College Mr. Jonathan Hutchinson, F.R.S., is to speak on October 8; Sir T. Clifford Allbutt, K.C.B., F.R.S., is to give an address at the University of Manchester, on October 1, on "Hospitals, Medical Science and Public Health"; and at University College, Bristol, on October 1, Sir Rubert Boyce, F.R.S., is to speak.

ACCORDING to foreign journals, steps are being taken by the commonwealth government in regard to the adoption of uniform food standards throughout Australia. Under the present system each state fixes its own standards, the result being considerable variance, and consequent annoyance and expense to manufacturers and importers. Now that a commonwealth analyst has been appointed, the way is cleared for federal action, and the proposal is made for a conference of commonwealth and state expert authorities with the object of discussing the basis of united legislation.

FOREIGN papers state that news has been received from the *Jacques Cartier,* the ship of the French Arctic Expedition, which started in April. After touching at Hammerfest, the ship crossed Barent's Sea and reached the Bailutsia Fjord in Novaya Zemlya, where extensive surveying was undertaken, leading to the discovery of several uncharted fjords. The first sledge expedition left the ship on July 25 with provisions for 20 days, intending to cross Novaya Zemlya from west to east, and it was followed by a second six days later. The expedition will probably not winter in Barent's Sea, but will return to Norway and remain there till the spring.

THE Central University of Equador at Quito publishes the following notice requesting exchanges in its monthly "Anales": "The University of Quito, desiring to increase its museums of zoology, botany, mineralogy and ethnology by means of exchanges with public and private museums, has resolved to invite the correspondence of parties who wish to exchange for collections of *Ecuadorian fauna, flora, etc.* Those who wish to have sent any particular specimen or collection (*e. g.,* an ornithological collection) have only to apply to the rector or the secretary of the Central University of Equador at Quito."

UNIVERSITY AND EDUCATIONAL NEWS

BY the will of the late John B. Brown, of Chicago, the bulk of his wealth, estimated at $7,000,000, is to be devoted to establishing and maintaining a technical school at Ipswich, Mass. A high-school education or its equivalent will be prerequisite for admission, thus placing the school among the higher institutions of learning.

BY the will of Henry J. Braker, of New York City, Tufts College receives a bequest of $500,000, to be known as the Henry J. Braker fund, the income to be used for the establishment of a school of commerce, accounts and finance. Mr. Braker also bequeaths $1,000,000 to establish a home for aged people.

PRESIDENT JOHN H. FINLEY announces that the Board of Aldermen has increased the an-

nual appropriation for the College of the City of New York by the sum of $40,000.

At the Carnegie Technical Schools, Pittsburg, two new buildings in the group for the School of Applied Science have just been erected, and will be ready for occupancy in October. They double the facilities for instruction in this department of the institution, giving 150,000 additional square feet of floor space. The construction is absolutely fireproof throughout, and the laboratory and class-room equipment is of the most modern type. John H. Leete, A.B., becomes dean of the school. New appointments to the faculty include Norman C. Riggs, M.S., assistant professor of mathematics; F. P. Colette, B.L., assistant professor of modern languages; F. W. Witherell, S.E., instructor in sanitary engineering, and John A. Schaeffer, Ph.D., assistant instructor in chemistry.

Dr. Charles H. Judd, professor of psychology at Yale University, has been elected dean of the school of education and head professor of the department of education at the University of Chicago, the appointment to take effect at the close of the present academic year.

Dr. Fletcher Bascom Dressler, associate professor of education in the University of California, has been appointed to the chair of philosophy and education in the University of Alabama, vacant by the removal of Professor Edward Franklin Buchner to the Johns Hopkins University.

Dr. G. A. Tawney, of the University of Illinois, has been elected professor of philosophy in the University of Cincinnati, to succeed Professor H. Heath Bawden.

Dr. Paul G. Wooley, who for the last five years has been director of the Siamese Government Serum Laboratory in Phrapatoom and chief inspector of health and medical adviser to the minister of the interior, has accepted the position of associate professor of clinical pathology in the University of Nebraska College of Medicine, Omaha.

At Northwestern University, Dr. George R. Mansfield, of Harvard University, has been appointed assistant professor of geology, to succeed Professor J. W. Goldthwait, who goes to Dartmouth College. Professor Mansfield will begin work in February, 1909. Mr. C. E. Decker has been appointed instructor in geology at Northwestern University for the first half of the present year. Mr. D. F. Higgins, Jr., has been appointed to an assistantship, and Professor J. H. Cline, of Bridgewater College, Virginia, to a fellowship in the same department.

In the department of geology of the University of Oklahoma, Dr. Chas. N. Gould, while still being retained as head of the department, has relinquished his work of teaching and is devoting his time to the new Oklahoma Geological Survey, of which he is the director. Dr. D. W. Ohern, until recently associate professor of geology at Bryn Mawr College, has taken up Dr. Gould's work in the university, and is being assisted by Mr. Pierce Larkin. Mr. Chester A. Reeds has resigned his position as associate professor in the department, having been elected to a position in the department of geology in the University of Cincinnati.

The following appointments have been made in the school of civil engineering, Purdue University: instructor in structural engineering, Mr. W. A. Knapp, graduate of the University of Illinois, class of 1907; instructor in hydraulic engineering, Mr. R. B. Wiley, graduate of the University of Michigan, class of 1906; assistant in surveying, Mr. J. H. Lowry, Purdue 1908; assistant in railway engineering, Mr. N. A. Lago, Purdue 1906.

The following appointments and changes are announced for the Worcester Polytechnic Institute for the ensuing year: Professor John E. Sinclair, who has held the position of professor of mathematics for thirty-nine years, retires on the Carnegie pension. Professor Levi L. Conant becomes the head of the department of mathematics on the retirement of Professor Sinclair. Two new appointments to the faculty have been made: Carleton A. Read, M.E., professor of steam engineering, who comes to the institute from the New Hampshire College of Agriculture and Mechanic Arts, and Arthur D. Butterfield, B.S.,

A.M., assistant professor of mathematics. Professor Butterfield is a graduate of the class of 1893, and was formerly instructor in civil engineering at the institute. For the past ten years he has been professor of mathematics at the University of Vermont. A number of appointments have also been made to the corps of instructors as follows: Robert H. Goddard, B.S., W.P.I., '08, instructor in physics; John F. Mangold, B.S., Cornell, Iowa, '07, instructor in civil engineering; Dr. W. F. Holman, University of Nebraska and University of Göttingen, instructor in physics; James A. Bullard, A.B., Williams, '08, instructor in mathematics; Royal W. Davenport, B.S., W.P.I., '08, instructor in civil engineering; Charles J. Adams, A.B., Amherst, '96, instructor in modern languages; J. Howard Redfield, A.B., Haverford, '99, and B.S. M.I.T., '02, instructor in mathematics; Albert A. Nims, B.S., W.P.I., '08, graduate assistant in electrical engineering; John C. Harvey, B.S., W.P.I., '08, Alden W. Baldwin, B.S., W.P.I., '08, and Richmond W. Smith, B.S., W.P.I., '08, graduate assistants in mechanical engineering.

H. J. EUSTACE has been appointed professor of horticulture in the Michigan Agricultural College and horticulturist of the experiment station. He graduated at the Michigan Agricultural College in 1901 and for five years was assistant botanist at the New York Agricultural Experiment Station at Geneva, N. Y., and for the past two years has been connected with the Fruit Storage and Transportation Investigations of the Bureau of Plant Industry, U. S. Department of Agriculture.

VICTOR T. WILSON, instructor in drawing, Cornell University, 1893 to 1903, professor of engineering drawing, State College (Pennsylvania), 1907–8, has been elected professor of drawing and design in the Michigan Agricultural College.

THE following are the new appointments in the science departments of the University of Maine: L. H. Merrill, Sc.D., professor of biological and agricultural chemistry; F. L. Russell, B.S., V.S., professor of bacteriology and veterinary science; Wallace Craig, Ph.D., professor of philosophy; L. E. Woodman, M.A., assistant professor of physics; V. R. Gardner, M.S., assistant professor of horticulture; W. A. Brown, B.S.A., assistant professor of animal industry; C. E. Lewis, Ph.D., associate vegetable pathologist; M. R. Curtis, M.A., assistant in biology; H. N. Conser, M.S., instructor in botany; E. M. Wallace, B.A., instructor in biology; J. L. Coon, Ph.B., tutor in physics; E. A. Garlock, B.S., tutor in physics; J. P. Farnsworth, B.S., tutor in drawing; R. K. Steward, B.S., tutor in civil engineering; A. G. Durgin, B.S., assistant in chemistry.

QUOTATIONS

AN EDUCATIONAL PARADOX

A EUROPEAN would be put to his wit's ends by the recent Chicago dispatch announcing that a professor of philosophy is about to exchange his university chair for one in a theological seminary in order to enjoy greater academic freedom. "America is more topsy-turvy than China!" the bewildered foreigner might ejaculate. "A university is the very citadel of intellectual liberty; a theological school, dogma's safest stronghold." Reference to catalogues would not clear his mind. The university in question declares that it "was not established with a view of forcing on the attention of students the creed of any particular church, but for the promotion of learning under influences conducive to the formation of manly Christian character." Its charter "carefully provides that no particular religious faith shall be required of those who become students at the institution." Surely, then, if students are not to be reminded of any doctrine, their instructors can not be expected to insinuate one into their professional utterances. In the seminary, on the other hand, teachers and learners are supposed to accept at least the broader Christian dogmas and to center their studies about these. Can the European, noting such facts at long range, be blamed for distrusting the whole story? The paradox may well confuse even our own countrymen who have not been

following contemporary tendencies in school and church. Professor George A. Coe's reported difficulties with the Methodists at Northwestern University and his acceptance of a chair at Union Theological Seminary are anomalous products of two conflicting movements in the educational and religious worlds —movements which may, in the course of years, lead to still more curious situations.

Andover's transfer to Cambridge and Union Theological Seminary's approaching shift to Morningside Heights reflect a yearning for university affiliations, born partly of intellectual discontent and partly of necessity. Unlike the college freshman, many theological professors and most theological students have felt the power of modern science and thought, and the weakness of dogmatics, apologetics, and Hebrew grammar as defenders of their faith. Not long ago, one of the largest seminaries in the country was peremptorily ordered by its students to modernize its curriculum; and, on every hand, the demand is being made that religious opinions be left to individuals, and the seminary teach biology, psychology, history, ethics, hygiene, and social reform. The result, at this hour, is incongruous in the extreme. While the universities are crying, "Let the seminaries come to us, that we may be spiritualized!" theological students ask for a chemical laboratory that they may be trained in modern scientific method. But the incongruity is natural. The forces of intellectual conservatism reside in the masses; they make themselves felt most acutely in the ordinary college simply because the latter is the meeting-place of culture and the average man. In the seminary, though, and particularly in those which have lived through an open controversy between dogma and liberalism, a handful of cultivated churchmen, half secluded and full of doubts, are seeking to square their beliefs with modern knowledge and their practises with the needs of modern life. Their own perplexities and their remoteness from the unschooled laity make them liberals. No wonder, then, that a training school for Protestant ministers may welcome a philosopher obnoxious to a nominally unsectarian university.—New York *Evening Post.*

DISCUSSION AND CORRESPONDENCE

MATHEMATICS FOR ENGINEERS

To the Editor of Science: I have followed the recent discussion of mathematics for engineers with much interest and with a great sense of satisfaction that at last the discussion of technical education is being published in a place where it must, perforce, be brought to the notice of our physicists; for our physicists (I mean to refer to them here in their capacity as teachers) have paid but little attention to the remarkably active discussion of technical education that has been going on for several years.

Something is wrong with technical education, that is quite evident, but I am not entirely satisfied with any diagnosis which up to this time has been given of the situation. I think that the most vital question which now confronts us in the field of technical education is how adequately to establish the *perceptive phase* of the physical sciences. In order that I may explain precisely what I mean by this expression, I must use an example:

> Nothing is more completely established by experience than the necessity of employing an active agent, such as a horse or a steam engine, to drive the machinery of a mill or factory, to draw a car, or to propel a boat. The common feature of every case in which motion is thus maintained is that *a force is exerted upon a moving body and in the direction in which the body moves.* Such a force is called an *active force,* and to keep up an active force involves continuous effort, or cost. A force which acts upon a stationary body, on the other hand, may be kept up indefinitely without cost or effort; such a force is called an *inactive force.* Thus, a weight resting on a table continues to push downwards on the table, a weight suspended by a string continues to pull on the string, the mainspring of a watch continues indefinitely to exert a force upon the wheels of the watch if the watch is stopped. The idea of an inactive force is applicable also to a force which acts upon a moving body, but at right angles to the direction in which the body moves. Thus, the force with

which a driver pushes vertically downwards on a moving cart is an inactive force, the vertical pull of the earth on a railway train which moves along a level track is an inactive force.

An active force is said to do work and the amount of work done in a given time is equal to the product of the force and the distance that the body has moved in the direction of the force.

This is taken almost verbatim from the text-book on "Elementary Mechanics" which was recently used with a freshman class in one of our best technical schools (only 126 pages of the text were covered during the excessively short time allotted to this subject) *and 43 per cent. of the class at the time of the final examination (counting the 20 per cent. who were so hopelessly deficient that they were not allowed even to try the final examination) were so deficient in physical imagination, or power of perception, or whatever one may prefer to call it, that they blindly calculated that the man was doing nearly twice as much work as the mule in the following problem:*

A cart moves northwards with a velocity of 6 feet per second, a mule pulls northwards on the cart with a force of 90 pounds, and a man exerts on the cart a downward force of 150 pounds. At what rate is work done by the mule and at what rate is work done by the man?

To have named the part of his body the man used in pushing down on the cart might have stimulated the perceptive powers of the dullest members of the class; indeed the instruction during the term did resolve itself many times into things as unreservedly elemental as this; but have we not a right to expect our students, at least at examination time when their greatest effort is put forth, to be able to handle abstract (!) problems like this of the hard-working cart driver and his pampered mule?

SCIENTIFIC PERCEPTION

I was greatly pleased to see Professor Swain bring up Sir William Hamilton's ideas, seventy years old. Perhaps your readers will welcome an idea from William Whewell which is also seventy years old. It is almost the only idea I was able to find years ago when I read the "Philosophy of the Inductive Sciences," but it is a creditable thing to have produced one idea; indeed, it would be a creditable thing in our time even to adopt ideas! Whewell says that ideas of perfect precision are a paramount possession (the four p's are Whewell's; he might well have omitted at least one of them as I do in the paraphrase). Nothing is so essential in the acquirement of real knowledge of physical things as the possession of precise ideas, not indeed because a perfect precision is necessary as a means for retaining knowledge, *but because nothing else so effectually opens the mind for the perception even of the simplest evidences of a subject.*

(In the final examination in elementary mechanics above referred to, the following note was appended to one of the questions:

A redundant or wrongly used word in answer to this question will be graded zero,

and a day or two after the examination a member of the faculty (*not* a professor of mathematics) quoted this note in derision, as if the only precision were numerical precision! May the shade of William Whewell protect us!)

In order to be able to define in a general way the perceptive phase of the physical sciences, let me distinguish two chief results of the scientific activity of the nineteenth century, namely, (1) an accumulated mass of fact, under which heading I would include all of the details of applied science, for indeed the most important and compelling facts that have been accumulated by the sciences are the facts which are incorporated in the settled doings of men, and (2) an established mode of thought and inquiry which may be designated, using a suggestive phrase of Bacon's, as "A new engine, or a help to the mind corresponding to tools for the hand." Here is an idea three hundred years old!

We continually force upon the extremely meager data which are obtained directly through our senses an interpretation which in its complexity and penetration would seem to be entirely incommensurate with the given data, and the possibility of this forced interpretation depends upon the use of two complexes, (*a*) a logical structure, that is to say,

a body of ideas and conceptions which operates for perception, and (*b*) a mathematical structure, which, in many cases, but by no means in all, supervenes and leads easily to an elaborate conclusion. These two complexes do indeed constitute a new engine which helps the mind as tools help the hand, and if the first (the perceptive phase of physical science) were insisted upon in our technical schools with approximately the same emphasis as pure mathematics, our students would not be so ridiculously perverted by mathematical superventions as to calculate that a two-horse-power steam engine would be required to drive a *willing* mule. But such is the earlier stage of technical education as it is to-day!

PHYSICS TEACHING AT FAULT

The fault, however, seems to me not to lie to any great extent with our teachers of mathematics. Their mode of presenting their subject is, I believe, in a general way correct, but I am firmly convinced that our mathematical courses at present include a great many topics which might well be omitted, and a thorough drill in descriptive geometry should certainly be included. I believe that too much time is devoted to the study of pure mathematics in our technical schools and too little time to the study of elementary physics and chemistry. It is certainly a fact, however, that a large number of our college and university teachers of physics are anything but enthusiastic as teachers, and the subject matter which they place before their students is certainly not up to the requirements of modern technical education. A real fault, as it seems to me, may be charged against our teachers of physics.

In the discussion of engineering education before the American Institute of Electrical Engineers on January 24, 1908, a great deal was said concerning the place of mathematics in technical education; and the exacting character of technical education, which is associated in most men's minds with the teaching of mathematics, was emphasized as important. In the old days mathematics was indeed the only scientific study which could be made definite and exacting. Nowadays, however, nearly every technical subject which is taught in the engineering school can be made as exacting as mathematics and, above all, the elementary sciences of physics and chemistry have been reduced to a basis which enables these sciences to be presented in a way which, in my opinion, must soon entirely revolutionize technical education. I believe that our engineers and many of our engineering professors fail to realize the change which has taken place in the teaching possibilities of elementary physics in the last ten or fifteen years, and therefore we find these men still expecting our teachers of mathematics to lift themselves and a large superstructure by pulling on their boot straps, these faithful teachers being held responsible for the most serious faults which underlie technical education. Let the heads of our technical schools look rather to their teachers of physics, demanding of them the best that modern science teaching can give, and allowing them the necessary time to accomplish what is desired.

ELEMENTARY PHYSICS TEACHING NECESSARY

I do not think we can look to our teachers of mathematics to establish the simple logical structure of physical science.

Nothing is more completely established in psychology nowadays than that ideas can not be formed out of the clear sky, as it were. They must be built of stuff, and *the rational study of the physical sciences especially in its earlier stages is the transformation of simple intimate knowledge into general ideas.* All elemental knowledge, such as the knowing how to throw a ball, how to ride a bicycle, how to swim, or how to use a tool, is locked in the marginal region of the mind (the region of reflexes) as a very substantial but very highly specialized kind of intuition, and the problem of the teaching of elementary physical science is the problem of how, by verbal and concrete suggestion, to drag this material into the field of consciousness, where it may be transformed into a generalized logical structure having traffic relations with every department of the mind. *An abstract treatment of the principles of elementary physics tends, more than anything else, to inhibit the influx of this elemental knowledge from the marginal regions into the field of consciousness and results in the building up of a*

theoretical structure which can have no effectual traffic with any mental field beyond its own narrow boundaries. Such a state of mind is nothing but a kind of idiocy, and to call it a knowledge of elementary science is weak scholasticism. . . . A large part of simple theoretical physics is constructed out of sensuous elements which are not habitually and fixedly associated with verbal forms of expression, and it is impossible to marshal these elements in any other way than by direct appeal, by sight of feeling, to the actual things which correspond to them.[1]

The equipment and methods of the physical laboratory are a necessity in the teaching of elementary physics. The point of view of many of those who are responsible for the arrangement of our technical courses is more or less confused in regard to elementary science instruction and it may be accurately characterized by a slight variation of a statement of Bacon's:

> Natural philosophy [in their minds] is not to be found unadulterated, but it is impure and corrupted by mathematics which ought rather to terminate natural philosophy than to generate or create it.

I have heard that near Naucratis, in Egypt, there was born one of the old gods, the one to whom the bird is sacred which they call the ibis; and this god's name was Teuth. And this god, or demigod, found out first, they say, arithmetic, and geometry, and logic, and gambling, and the art of writing. And there was then a king over all Egypt, in the great city which the Greeks called Thebes. And Teuth, going to Thebes, showed the king all the arts he had invented, and said they should be taught to the Egyptians. But the king said: "What is the good of them?" And Teuth telling him at length of each, the king blamed some things and praised others. But when they came to writing: "Now, this piece of learning, O king," says Teuth, "will make the Egyptians more wise and more remembering; for this is physic for the memory and for wisdom." But the king answered: "O most artful Teuth, it is one sort of person's business to invent arts, and quite another sort of person's business to know what mischief or good is in them. And you, the father of letters, are yet so simple-minded that you fancy their power just the contrary of what it really is; for this art of writing will bring forgetfulness into the souls of those who learn it, because, trusting to the external power of the *scripture* and *stamp* of other men's minds, and not themselves putting themselves in mind, within themselves; it is not medicine of divine memory, but a drug of memorandum that you have discovered, and you will only give the reputation and semblance of wisdom, not the truth of wisdom to the learners: for[2] becoming hearers of many things, yet without instruction, they will seem to have manifold opinions, but be in truth without any opinions; and the most of them incapable of living together in any good understanding; having become seeming-wise instead of wise."

I always think of this prognostication of the old Egyptian king concerning the influence of letters when I consider what may be the true path through the tremendously widened and at present greatly confused field of human endeavor which has come with the discovery of physical science. We are now, in regard to science, in the midst of something like the pandemonium which was imagined by Socrates as a possibility in the field of letters. We have, indeed, become hearers of many, many things, and we seem to have manifold opinions; and, although I believe we are not really without opinions, I certainly do believe that many of us do not take sufficient pains to make ourselves understood when we attempt to express what opinions we may truly have. (It may be justly said, I think, that the voluminous discussion of technical education which has taken place during recent years, especially that which has taken place before our engineering societies, is but slightly edifying.) Nor do I believe that we are *incapable* of living together in any good understanding. As to being seeming-wise instead of wise, we should in all humility admit that wisdom is a

[1] From a paper on "The Study of Science by Young People," by W. S. Franklin, *Proceedings of the Twelfth Annual Meeting of the New York State Science Teachers' Association*, pp. 65–94.

[2] This powerful story of the mythical discoverer of writing was quoted thirty-five years ago by a very severe writer, who inserted the following parenthesis at this point "now *do* listen to this, you cheap education mongers." I believe, however, that technical educators are as far removed as any from the cheap type, except only the one who knows of no other kind of precision but the precision of numbers.

truly wonderful state, not presuming to have reached it in its perfection.

But let me return to the question of the perceptive phase of the physical sciences. A splendid example of almost pure perception is the recent work of Rutherford and others on radio-activity which is based on what would seem to be an absurdly slender group of observable effects. No one can overestimate the power of men who do such work as this. My chief business, however, is the *teaching* of physics; as a teacher I am concerned with average men; and every year I am more and more amazed to see the feebleness with which men hold things in the mind, and more and more impressed with the tremendous power with which men hold things in the hand, a power which, as Plato says, encompasses with eternal security an ancient polity and ancient divisions of rank founded on possession, but which also, alas! as Ruskin says, too often takes the name of Christ in vain and leagues itself with his chief enemy covetousness, which is idolatry.

W. S. Franklin

What can be done to enhance the value of the work of the Bureau of Standards to the chemical industries?

The greater part of the scientific work done in the United States is accomplished through two agencies, the universities and technical schools on one hand and the bureaus of the government on the other. As regards the latter, the principle that the government should undertake, in the main, only such work as can not efficiently be handled by unofficial enterprise, is generally accepted as sound and has, with some exceptions, been adopted as a policy by the bureaus. It must be admitted that it would not be well to draw such a distinction, or any distinction, too sharply or rigidly. To attempt this would certainly impair the usefulness of the work of the governmental departments. But, broadly speaking, it is not impracticable to avoid needless competition with scientific research carried on by other instrumentalities.

It is an indubitable fact that some lines of scientific research lie farther away from practical applications than do others. Those can be and are well cared for by educational institutions. On the other hand, experience has shown that scientific investigations which bear more directly upon the industries can not be so satisfactorily undertaken without government aid and are more or less seriously neglected when left wholly to private enterprize. Such technical researches are by their nature (costliness, necessity of continuity, direct bearing on legislation, etc.) appropriate subjects for governmental treatment. The success and value of the official work of the United States authorities on road building, on the testing of materials of construction and of foods and drugs, and on standards of measurement, are approved and appreciated alike by scientific men and by the general public, and scarcely require special emphasis here.

It is fortunate that popular recognition is accorded to this branch of governmental work, not only in a liberal degree, but also in a way that harmonizes with the principle enunciated above. So long as the bureaus concentrate their labors on the solution of problems of practical interest, so long will they enjoy the approval and support of the public. Just in the measure that they allow themselves to be diverted to the study of scientific questions lying far afield from practical industrial applications, will the public interest cool and the necessary appropriations become increasingly more difficult to obtain, and this quite apart from the intrinsic interest or importance of the work done. As an example of the sort of scientific questions referred to, determinations of the atomic weights of the elements may be cited as typical. If the considerations advanced here have any validity, such determinations had better be left for other institutions and remain untouched by the government. We are free to admire the excellence of the work as much as we like, and to extoll its importance, and we may still without inconsistency take the stand that such work is not within the proper scope of governmental departments, because, (1) it can be and is well taken care of by other agencies, (2) it is not of direct industrial or so-called "practical" application, (3) it is not calculated to com-

mand the cordial approval of the people and therefore of congress, (4) it withdraws to an appreciable degree the energies of the bureaus undertaking it from the attack of a class of problems that demand a sort of investigation which other organizations or individuals have been unable or unwilling to give. The question of atomic weights has been selected as typical of a class of scientific inquiries, for the reason that the work done in that direction by the Bureau of Standards is of the highest character and the argument in favor of its inclusion in the scope of bureau activities is the strongest that can be brought in behalf of any scientific work of the category to which it belongs. It is, however, not a question, as I apprehend it, of whether this bureau can do such work well, but rather of whether any bureau should do it at all.

The reply is obvious, that, if the public does not approve of the government doing such work it is because the public does not understand it; therefore educate the public, but do not stop the work. It is possible, however, that the public understands the wider bearings of the questions involved very well, although not very familiar with details. Every one of the bureaus doing scientific work was organized explicitly and absolutely for utilitarian purposes. Every argument used before the congress to secure appropriations needed for organization and maintenance was based on the direct practical usefulness of the bureaus to the commerce and industries of the country and to the transaction of the business of the government itself. Those arguments are looked upon by the people at large as pledges, and in my opinion it is right that it should be so. The utilitarian aim should be first. It can not be doubted that, if this aim is conscientiously kept in mind, incidentally much that possesses a wider scientific interest will be brought out, in the end as much perhaps as if the aim had been primarily scientific in the narrower sense. After all, it should not be forgotten that the industries have contributed no less to the sciences than the sciences to the industries.

In any event, raising the question whether and how the Bureau of Standards may be made still more useful to those engaged in the technical or scientific practise of chemistry, ought not—and I am sure will not—be construed as a reflection upon the valuable work done by it in the past.

The same reasons which have made it necessary to supply the industries with official standards of weight and of volume make it desirable that chemical standards should also be furnished for those industries which are dependent upon chemical processes. It is scarcely to be assumed that the chemical laboratories devoted to commercial technical work should in all or most instances command the time or the skill to establish their own standards. Such laboratories employ methods of analysis that yield results reasonably concordant among themselves, but that are not necessarily in conformity with absolute standards nor with those obtained by other laboratories of the same type. In a word, the methods are, to a certain degree, empirical. This is a fact not subject to control. It is conditioned by the nature of the work and must as such be reckoned with. It is an evil which constantly gives rise to friction between buyer and seller, between manufacturer and consumer. A remedy for this evil which has repeatedly been and still is advocated is the introduction of uniform methods of analysis. This remedy is, however, both inadequate and dangerous. Inadequate, because it is impossible so to specify every step of an analytical process as to secure with certainty identical execution and identical results from it at the hands of workers in different laboratories. Dangerous, because it hampers the development of improved methods and tends to make a mere machine of the technical chemist. A better remedy is at hand. This is, to place at the disposal of all laboratories interested, chemicals which are officially standardized, so that by whatever process a given chemist operates, he may check his results by the standard material, just as he now checks his thermometers or his weights through the aid of the Bureau of Standards. He will thus, if his methods are bad, soon discover the fact and abandon them; if they are concordant among themselves, but not with the absolute

standard, he will apply the proper correction. In cases of dispute between two laboratories, an analysis by each of the standardized sample, each working by its usual method, will usually lead to a satisfactory agreement.

The materials which it is proposed to standardize fall into two groups. The first group comprises substances to be employed for standardizing volumetric solutions. These may be either the solutions themselves, or compounds of exactly known content used in establishing the true titer of the solutions belonging to the industrialist's laboratory. In the case of about six of the most used and most permanent, it would probably be well to furnish the solutions and also the standard compounds. The second group comprises standardized samples of commercial materials, by the use of which the manufacturer can control his entire analytical process. This work has already been begun. Its development must naturally be slow, since the field is immense, and in some cases special industrial laboratories have perfected methods of analysis which for commercial reasons have never been published and which are superior to those in general use or to those which would be at the command of the bureau. Exceptional cases of this kind need not, however, stand in the way of the adoption of the general scheme. To decide what portion of the whole field should be first occupied and what left to future growth is a matter that would require very careful study and need not be even touched on here. The question whether the standard solutions or substances should be furnished by the consumer and standardized by the bureau or whether they should be furnished outright by the bureau is a matter of detail which practical considerations would settle. The cost of executing such a programe as that suggested need not be a serious obstacle. From the standpoint of the manufacturer it would be economy to pay very liberal fees for the work, especially in view of the fact that the standardized materials would be consumed in small quantities only and mainly for the purpose of establishing secondary standards.

Whether it is desirable for the bureau to undertake to work out standard methods of analysis, is a question that may fairly be looked upon as an open one. For myself I should be inclined to answer it in the negative. The scope of work is wide enough without this. The difficulty which any institution must have in deciding for the industrial laboratory which are the methods that would be practical for it are insuperable. A method that would be eminently practical for one would be the reverse for another having command of facilities more or less wide. Moreover it is impossible for any outsider to know what the analytical problems are which the industrialist has to handle, and in very many cases the latter will on no account furnish the information. Nevertheless, while for the reasons stated, the writer does not believe it to be wise for the bureau to make the investigation of analytical methods a part of its functions, yet it must of necessity investigate many such methods as an incident in the carrying out of other work, and it will, of course, not refrain from giving to the world the benefit of such work by timely publication.

The chemical profession in this country is only now coming to a consciousness of itself. When it has fully done so, it will doubtless have a Bureau of Applied Chemistry of its own, together with other good things, but the day is probably still distant. It owes it to itself, in the meantime, neither to be backward in acknowledging the great work that the Bureau of Standards has already accomplished, nor in demanding that its scope should be extended and its relations be made more intimate with our chemical industries, whose future is already looming up greater than any man can now fully realize or forecast.

Launcelot Andrews

St. Louis,
July 24, 1908

SCIENTIFIC BOOKS

The Work of John Samuel Budgett, Balfour Student of the University of Cambridge. Being a Collection of his Zoological Papers, together with a Biographical Sketch by A. E. Shipley, F.R.S., and Contributions by

RICHARD ASSHETON, EDWARD J. BLES, EDWARD T. BROWNE, J. HERBERT BUDGETT and J. GRAHAM KERR. Edited by J. GRAHAM KERR. Pp. x + 494; 28 plates; 173 figures in the text. Cambridge University Press, 1907.

John Samuel Budgett died January 19, 1904, at the age of thirty-two, from malarial fever contracted during his last and successful expedition to Africa in quest of the long and eagerly sought early development of *Polypterus*. The beautiful volume prepared by his friends and colleagues is a fitting memorial of his life and work and one that stirs a keen sense of the loss that science suffered by his untimely death. A collection of Budgett's own works and of others based on his material is preceded by an excellent biographical sketch by Mr. Shipley. From this we learn that his early interest in natural history was encouraged by his father's friends, Professor W. K. Parker and the Rev. Dr. Dallinger, and later by Dr. Lloyd Morgan, but until his entrance to Cambridge University he was largely self taught. The remarkable abilities he displayed at Cambridge brought him the opportunity to accompany Mr. Graham Kerr on his brilliantly successful expedition to Paraguay in 1896–7, the principal result of which was to make known the development of *Lepidosiren*. On this expedition Budgett gave especial attention to the amphibia, afterwards publishing a valuable account of their breeding habits and of the development of Phyllomedusa. The principal result for him was, however, to arouse his determination to attack the development of the crossopterygians; and to the search for this material the next five years were devoted with indomitable persistency and courage. In the effort to procure the early stages of *Polypterus and Calamicthys*, and also of *Protopterus*, he made four successive expeditions to Africa, the last of which, in 1903, was crowned with success but cost him his life. The first expedition, to the Gambia River in 1898–9, failed in its main object, but in the face of great difficulties the breeding time of *Polypterus* was determined and valuable additions to our knowledge of the fauna of the Gambia were made. In a second attempt, made in the same region during the rainy season of 1900, the nests and larvæ of *Protopterus* were discovered and a single larval stage of *Polypterus* was procured which formed the subject of an important memoir published in 1901. His diaries of the expedition give a vivid impression of the courage and enthusiasm with which he pursued his work in the tropical swamps amid incessant heavy rains, and at times attacked by fever. Upon his return to Cambridge he became assistant curator in the zoological museum and delivered lectures on the geographical distribution of animals. In 1902 he was elected to the Balfour studentship, the "zoological blue ribbon of Cambridge," and, with an additional grant from the Zoological Society, was enabled to embark on a third expedition, to the Victoria Nile. For the third time he failed, but held to his purpose. The final and successful attempt was made in 1903. At Assé, on the river Niger, he at last succeeded in artificially fertilizing the eggs of *Polyterus* and in obtaining a practically complete series of the stages of development. But the climate had done its deadly work. Returning to England be began to work out his results, but suffered from recurrent attacks of malarial fever to which within a few months he succumbed, his death occurring on the very day for which a paper by him on the development of *Polypterus* was announced for the Zoological Society. He had finished his drawings of the external features of the early development, but it remained for Professor Kerr to prepare the sections and work out the results in detail.

In the memorial volume are brought together ten of Budgett's papers, the most important of which deal with the development of the skeleton and urino-genital system in *Polypterus*, the early development of *Protopterus*, and that of *Phyllomedusa*. Other less technical papers deal in an interesting way with the general natural history of the tropical regions that he visited. The remaining papers of the volume, based on Budgett's material, include, among others, Professor Graham Kerr's very valuable memoir on the development of *Polypterus;* another on the develop-

ment of *Gymnarchus* (the first of the Mormyridæ to be made known embryologically) by Richard Assheton; and shorter articles by Mr. Boulenger on the fishes of the Gambia, by Dr. Bles on the development of the Anura; and one by Mr. Browne on a fresh-water medusa, discovered by Budgett in the delta of the Niger, that seems to be identical with the Limnocnida found in Lake Tanganyika. It is impossible here to review the results of these works in detail, but a special word should be spoken in commendation of the excellence, and often the truly artistic quality, of the illustrations, many of which are from Budgett's own drawings.

Budgett showed a rare union of technical skill and morphological insight in laboratory research with uncommon abilities as a field naturalist. His diaries reveal a true lover of nature, one having a wide range of interests in living things, alertly awake to natural beauty, and steadfastly unsparing of himself in the pursuit of his special aim. His was not the only life to be sacrificed in the pursuit of the *Polypterus* development. Nathan R. Harrington died at Atbara in the summer of 1899 while leading an expedition sent out from Columbia University on the same quest. The results attained through Budgett's success are of great and permanent value to science, but they have cost a heavy price.

W.

A Popular History of Astronomy during the Nineteenth Century. By Agnes M. Clerke. New York, The Macmillan Company. 1908. Pp. vi + 489. $2.75 net.

This is a reprint, without change, of the fourth edition, which appeared in 1902 and was widely reviewed at that time. This well-known work is accurate, lucid and interesting. It is already on the shelves of every astronomer's library, but should more universally be found in school and circulating libraries.

It is to be regretted that the few errors and omissions which are to be found in the fourth edition were not corrected in this reprint. Failure in this respect is doubtless due to the lamented death of the author in 1907. The publishers, however, should have had made such obvious and easy corrections as the change in the date of the death of Lassell from 1818 to 1880 (p. 83), and the substitution of the word "gemination" for "germination" when describing the canals of Mars (p. 279), and should have supplied in Table V. the missing but easily obtainable data regarding focal lengths of various telescopes listed therein.

Storrs B. Barrett

SCIENTIFIC JOURNALS AND ARTICLES

The July number (volume 9, number 3) of the *Transactions of the American Mathematical Society* contains the following papers:

W. H. Roever: "Brilliant points of curves and surfaces."

Oswald Veblen: "Continuous increasing functions of finite and transfinite ordinals."

E. J. Wilczynski: "Projective differential geometry of curved surfaces (third memoir)."

A. L. Underhill: "Invariants of the function $F(x, y, x', y')$ in the calculus of variations."

R. G. D. Richardson: "The integration of a sequence of functions and its application to iterated integrals."

SPECIAL ARTICLES

DEGENERATION, ALBINISM AND INBREEDING

In a paper before the American Philosophical Society last spring I showed that often when the two parents have any organ or quality A in two conditions, A + and A —, of which the former is a highly developed or progressive condition, the latter a poorly developed or even absent condition, the former condition will regularly dominate over the latter. In the particular case of human hair color we find, for example, that children are not ordinarily darker than their darker parent. Consequently, if both parents have flaxen hair the children will have hair of the same sort. From this principle, applied generally, it follows that when both parents have an organ in a low condition of development it will be so also in all of their children. This principle explains the persisting or increasing degeneration in the descendants of two degenerate parents.

When one parent has an organ in a minus

condition and the other in a plus condition the condition of the organ in the children will depend upon the germ cells (and hence on the parents) of the advanced parent. If half of its germ cells are in the minus condition, as may be the case, half of the children will have the organ in question in the minus condition. Even if both parents are in an advanced condition, if they both have the less advanced condition recessive, one quarter of their offspring will have the organ in a minus condition.

The foregoing principles help us to understand the reason for the degeneration that sometimes, but not always, follows inbreeding. If the children can not rise above the level of their parents but may fall below in respect to any organ, it is plain that if brothers and sisters were to mate the average of the offspring would rapidly run down hill to the zero condition of the organ. In the mating of cousins the same result would tend to occur, but not so rapidly and certainly. The more foreign blood introduced the less the danger of degeneration.

Another class of degeneration is illustrated by albinism. Studies that Mrs. Davenport and I have been making show that there are in human hair two pigments, black and red, occurring in various dilutions and combinations, as will be more fully set forth in our paper on human hair color to appear shortly in the *American Naturalist*. There are, however, cases of black (*N*) hair with no red (*r*) pigment, and of yellow or red (*R*) hair without black pigment (*n*). The gametic formula of the former is *Nr* and of the latter *nR*. The grandchildren of *Nr* and *nR* consorts will have hair of either of four kinds: black-and-red (*NR*, chestnut, or mahogany colored), jet black (*Nr*), clear yellow or red (*nR*), and colorless (*nr*); the latter are albinos. Studies that I have been making on albinos reveal an ancestry in conformity with this hypothesis. We see, then, that albinism is not a sport occurring in wholly arbitrary fashion; but a necessary, predictable result of certain combinations of gametes. The only part that inbreeding plays is to make more probable the necessary combination of gametes. The degeneration in this case follows from the union of two negative factors in dihybrids; and this is a common cause of degeneration.

CHAS. B. DAVENPORT

THE QUESTION OF CYCLOPIA, ONE-EYED MONSTERS

Two summers ago I found it possible to produce one-eyed fish embryos by means of $MgCl_2$ solutions in sea water.[1] At that time the spawning season of the fish used, *Fundulus heteroclitus*, was nearing a close, so that it was impossible to obtain material showing the early conditions of the defect or to rear the embryos in order to observe their actions after hatching.

During the present summer more extensive experiments have confirmed the fact that cyclopean embryos may be produced in any number desired by treating the eggs with $MgCl_2$ or $Mg(NO_3)_2$ solutions. The effect seems due to the Mg ion in the presence of certain sea-water salts. The embryos may be hatched and the cyclopean eye seems functional, many of the fish swimming in a normal fashion and responding to light. These free-living cyclopean fish may be kept for as long a period as the normal swimming embryos, a period of eight or ten days, after hatching, at which time all die of starvation, since the entire content of the yolk-sac has been absorbed and no other food is furnished. The cyclopean individuals could doubtless be reared if their proper food was known.

A study of these cyclopean embryos from the first appearance of the optic vesicles to hatching, both in life and sections, has proved that the earliest indication of an eye is just as truly cyclopean as it will be later. All degrees from a perfectly single organ through various conditions of doubleness to two intimately approximated optic cups may be found in young embryos. My former statement that the cyclopean eye resulted from a fusion of the elements of the two eyes after their formation, a statement based on comparisons of cyclopean eyes in late stages of development, is incorrect, as is also a similar idea advanced by Dr. Mall in his recent paper.[2]

[1] Stockard, *Archiv für Entw.-Mech.*, XXIII., 1907.

[2] Mall, *Jour. Morphology*, XIX., 1908.

The cyclopean defect, as Spemann[3] contended, is present from the first in the same condition that it will continue throughout development.

In mammalian cyclopean monsters the nose is prevented from descending as it normally does by the presence in its path of the median eye. The nose is thus above the eye and shows as a proboscis-like mass on the forehead. The nasal pits in the fish are laterally placed above the mouth and slightly antero-median of the two eyes. In the cyclopean monsters the two pits are generally united, though at times separate, and are situated unusually far forward and above the eye. The mouth in the normal fish is anterior, the lips projecting beyond the forward limits of the head. In cyclopean fish the median eye occupies this position and often projects forward, suggesting a miner's lantern in the front of the head. This anterior eye prevents the forward development of the mouth, so that its structures remain in a ventral position and hang down as a proboscis-like organ, recalling in a striking way the nose of the mammalian cyclops, and in fact the two are due to like causes. In the mammal the nose is prevented in its downward growth by the median eye, while in the fish the antero-median eye prevents the forward growth of the mouth arrangements.

The magnesium solutions induce the development of two types of one-eyed monsters. First, the true cyclocephali which may have a perfectly single median eye with one optic nerve, one lens and one pupil, or a median eye showing more or less double nature, having two optic nerves and paired retinæ, or in others entirely double eyes with two lenses and two pupils present. A second type of monster, which is new, may be termed *Monstrum monoculum asimmetricum,* a monster with one asymmetrical eye, since it has only one perfect eye, which is one of the normal pair of eyes occupying its typical lateral position. The one eye in all cases is perfect while its mate may be represented by either a small eye, a mere cellular mass indicating an optic cup, or again all evidence of the second optic cup may be wanting. This peculiar one-eyed condition occurs in a great many of the embryos in the various Mg solutions. Should such a monstrosity have been caused by mechanical injury, as cutting or pricking certain early brain areas, the evident conclusion would have been that one of the eye anlagen had been injured while the other had not. Any other interpretation would have been faced by the above conclusion as a criticism and it would have been almost impossible to meet. In the case of the Mg action it is clear that such embryos have developed one eye normally while the production of the other was in some way inhibited, although the anlagen of both were exposed to the chemical.

These embryos throw interesting light on the development of the crystalline lens. In many of them a lens forms from the ectoderm and differentiates independently of the influence of an optic cup. Some embryos with one lateral eye and the other wanting have a perfect lens on the eyeless side. The lens lies freely in mesenchymous tissue and is disconnected entirely from any portion of the central nervous system. Several experimenters, Lewis[4] and others, have held that the lens during its development is in a dependent relationship with the optic cup and they have shown that if the optic cup be removed a lens fails to form. The fish embryos are against the universal application of such a view. Spemann[5] has recently found that in one species of frog, *Rana esculenta,* the lens may arise independently of the optic cup stimulus and is self-differentiating.

To conclude—experiments now show that cyclopean fish embryos may be produced by the action of two salts of magnesium in sea-water solutions. The embryos exhibit various conditions of the cyclopean defect from the earliest appearance of the optic vesicles. Cyclopia is *not* due to a subsequent union or fusion of the two eye elements after their free and distinct origin.

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[3] Spemann, *Zool. Jahrbuch,* Supp. VII., 1904.

[4] Lewis, *Am. Jour. Anatomy,* 1904.

[5] Spemann, *Zool. Anzeiger,* XXXI., 1907.